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Electrochemical Energy Storage Subsystems Study

FINAL REPORT

Volume 2 of 2

Prepared For
NASA LEWIS RESEARCH CENTER
CLEVELAND, OHIO 44135
CONTRACT NAS3-21962
SEPTEMBER 1981

prc

PRC Systems Services Company
A DIVISION OF PLANNING RESEARCH CORPORATION

Electrochemical Energy Storage Subsystems Study

FINAL REPORT

Volume 2 of 2

Prepared For
NASA Lewis Research Center
Cleveland, Ohio 44135
Contract NAS3-21962
September 11, 1981

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September 11, 1981

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Attention: Don F. Hoffman, Contract Specialist, MS500-305

Subject: Submission of Final Report

Reference: Contract Number NAS3-21962,
Electrochemical Energy Storage Subsystems Study

Gnetlemen:

In compliance with the referenced contract, the specified copies of the Electrochemical Energy Storage Subsystems Study Final Report are hereby submitted.

Should you have any questions, please contact the undersigned at (205) 883-2900.

Very truly yours,

PRC SYSTEMS SERVICES

Fred Q. Miller

Fred Q. Miller
Project Manager

FQM/bjs

Enclosures: As stated

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16. Abstract

The effects on life cycle costs (LCC) of major design and performance technology parameters are examined for multi-kW LEO and GEO energy storage subsystems using NiCd and NiH_2 batteries and fuel cell/electrolysis cell devices. Design, performance and LCC dynamic models are developed based on mission and system/subsystem requiremens and existing or derived physical and cost data relationships. The modles are exercised to define baseline designs and costs. Then the major design and performance parameters are each varied to determine their influence on LCC around the baseline values. Results and analyses are discussed and concluding recommendations are made.

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Final Report

ELECTROCHEMICAL ENERGY STORAGE SUBSYSTEMS STUDY

by

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PRC SYSTEMS SERVICES

Prepared For

National Aeronautics and Space Administration
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Contract NAS3-21926

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FOREWORD

This document is the final report for the "Electrochemical Energy Storage Subsystems Study", performed by PRC/SSc under contract NAS3-21962 with NASA-Lewis Research Center. The effective date of the contract is September 26, 1979. The basic contract study encompassed the study of subsystems consisting of fuel cells/electrolysis cell and battery cell type subsystems at 25, 50, 100 and 250 kW in low earth orbit. A modification was made, dated September 30, 1980, which expanded the study scope to include the geosynchronous case at 25 kW power level, again using both types of energy storage devices.

NiCd

Program Addendums for Technology Variations vs LCC

(Major Parameters)

Depth of Discharge (Capacity Variable)

```
420 FOR GØ = 1 TO G9
514 DØ, D9 = .05 + .05 * GØ @
  GOTO 600
690 D = 1
720 EØ = C1 * K1 * DØ
805 P = 1 @ GOTO 853
4661 RESTORE 506 @ NEXT GØ
```

Rated Cell Capacity

```
420 FOR GØ = 1 TO G9
670 C1 = -10 + 30 * GØ
680 GOSUB 4925
690 GOTO 800
4661 RESTORE 506 @ NEXT GØ
```

Cell Life (Capacity Variable)

```
420 FOR GØ = 1 TO G9
430 L2 = .6 + 1.1 * GØ
440 K = 1
514 C = L2
690 D = 1
810 DØ = D9 @ GOTO 901
4661 RESTORE 506 @ NEXT GØ
```

Hardware Life Cycles (Capacity Variable)

```
420 FOR GØ = 1 TO G9
430 N8 = 2 + GØ
690 D = 1
4661 RESTORE 506 @ NEXT GØ
```

Depth of Discharge (Capacity Fixed)

```
420 FOR GØ = 1 TO G9
514 DØ, D9 = .05 + .05 * GØ @
  GOTO 600
805 P = 1 @ GOTO 853
4661 RESTORE 506 @ NEXT GØ
```

Discharge Current (Capacity Variable)

```
420 FOR GØ = 1 to G9
810 IØ = 10 * GØ
820 EØ = IØ * T1
830 C1 = CEIL(EØ/K1/D9/5) *5
840 GOSUB 4950
4661 RESTORE 506 @ NEXT GØ
```

Cell Life (Capacity Fixed)

```
420 FOR GØ = 1 to G9
430   L2 - .6 + 1.1 * GØ
440   K = 1
514   C = L2
810   DØ = D9 @ GOTO 901
4661  RESTORE 506 @ NEXT GØ
```

Hardware Life Cycles (Capacity Fixed)

```
420 FOR GØ = 1 to G9
430 N8 = 2 + GØ
4661 RESTORE 506 @ NEXT GØ
```

NiH_2

Program Addendums for Technology Variations vs LCC

(Major Parameters)

Depth of Discharge (Capacity Variable)

```
420 FOR GØ = 1 to G9
514 DØ, D9 = .175 + .075 * GØ @
  GOTO 600
690 D = 1
720 EØ = C1 * K1 * DØ
805 P = 1 @ GOTO 853
4661 RESTORE 506 @ NEXT GØ
```

Rated Cell Capacity

```
420 FOR GØ = 1 TO G9
670 C1 = -10 + 30 * GØ
680 GOSUB 4925
690 GOTO 800
4661 RESTORE 506 @ NEXT GØ
```

Cell Life (Capacity Variable)

```
420 FOR GØ = 1 TO G9
430 L2 = 1.75 + 1.25 * GØ
440 K = 1
514 C = L2
690 D = 1
810 DØ = D9 @ GOTO 901
4661 RESTORE 506 @ NEXT GØ
```

Hardware Life Cycles (Capacity Variable)

```
420 FOR GØ = 1 TO G9
430 N8 = 2 + GØ
690 D = 1
4661 RESTORE 506 @ NEXT GØ
```

Depth of Discharge (Capacity Fixed)

```
420 FOR GØ = 1 TO G9
514 DØ, D9 = .175 + .075 * GØ @
  GOTO 600
805 P = 1 @ GOTO 853
4661 RESTORE 506 @ NEXT GØ
```

Discharge Current (Capacity Variable)

```
420 FOR GØ = 1 TO G9
810 IØ = 10 * GØ
820 EØ = IØ * T1
830 C1 = CEIL(EØ/K1/D9/5) * 5
840 GOSUB 4950
4661 RESTORE 506 @ NEXT GØ
```

Cell Life (Capacity Fixed

```
420 FOR GØ = 1 TO G9
430 L2 = 1.75 + 1.25 * GØ
440 K = 1
514 C = L2
810 DØ = D9 @ GOTO 901
4661 RESTORE 506 @ NEXT GØ
```

Hardware Life Cycles (Capacity Fixed)

```
420 FOR GØ = 1 TO G9
430 N8 = 2 + GØ
4661 RESTORE 506 @ NEXT GØ
```

Fuel Cell

Program Addendums for Technology Variations vs LCC

(Major Parameters)

FCU Current Density

```
195 FOR GØ = 1 TO G9
202 J1(1) =  50 + 50 * GØ
  @ GOTO 210
245 GOTO 270
295 L(1) = U @ GOTO 310
2325 NEXT GØ
```

FCU Voltage

```
195 FOR GØ = 1 TO G9
196 E1, E1(1) = 1 + .1 * GØ
245 GOTO 270
275 GOTO 310
315 GOTO 330
2325 NEXT GØ
```

FCU Active Area

```
195 FOR GØ = 1 TO G9
212 C1 = 6.0 + 60 * GØ
2325 NEXT GØ
```

FCU Life

```
111 RESTORE 113
112 READ GØ(1)....GØ(9)
113 DATA 32000, 21500, 16000, 13000,
  10750, 8000, 6500, 5400, 4300
195 FOR GØ = 1 TO G9
196 L(1) = GØ(GØ)
282 NØ(1) = CEIL(T3 * NØ/L(1))
285 GOTO 310
2325 NEXT GØ
```

FCU Hardware Life Cycles

```
111 RESTORE 115
112 FOR I = 1 TO G9
113 READ GØ(I)
114 NEXT I
115 DATA 2, 3, 4, 5, 6, 8, 10, 12, 15
182 FOR GØ = 1 TO G9
184 N(1), NØ(1) = GØ(GØ)
275 GOTO 310
2325 NEXT GØ
```

```
1 !  "NiCd","FH",2
2 OPTION BASE 1
3 COM G,X(96) ,INTEGER C9,C0,G1,G2,G9,L,N,I,J,U,Q(3),A4,B4 ,SHORT T(14),S(14),K0,K1,K2,K5,K6,U1
4 SHORT A,B,C,E,N,Y,Z,A0,A1,A2,A3,A5(4,14),B0,B1,B2,B3,B5(4,14),C0,C1,C2,C3,C4,D0,E0,H0,I0,I1
5 SHORT L0,L1,L2,L9,M0(4,14),M1(4,14),M2(4,14),M3(4,14),M4(4,14),M5(4,14),M6(4,14),M7(4,14)
6 SHORT M8(4,14),M9(4,14),N0,N1,N2,N3,N4,N5,N6,N7,N8,O0(4,14),O1(4,14),O2(4,14),O3(4,14),P0,P1,P
7 SHORT P2,P3,P4,P5,P6,Q0,Q1,Q2,R0,S0(6),S1(7),S2(5),S3(7),S4(7),S5(3),T0,T1,T2,T3,T4,T5,T6
8 SHORT U0(4,14),U1(4,14),U2(4,14),U3(4,14),U4(4,14),U5(4,14),U6(4,14),U7(4,14),U8(4,14),U9(4,14)
9 SHORT V0,V1,V2,V3,V4,W(7),W0,W1,X0(2),X1(2),X2(2),X3(2),Y0,Y1,Y2,Y3,Z0,Z1,Z2,Z3,Z9,F0(9),F1(7)
10 ASSIGN# 1 TO "DATA1"
11 READ# 1,1 ; O0(,)
12 READ# 1,2 ; O1(,)
13 ASSIGN# 1 TO *
14 ASSIGN# 2 TO "DATA2"
15 READ# 2,1 ; O2(,)
16 READ# 2,2 ; O3(,)
17 ASSIGN# 2 TO *
18 ASSIGN# 3 TO "DATA3"
19 READ# 3,1 ; U1(,)
20 READ# 3,2 ; U2(,)
21 READ# 3,3 ; U3(,)
22 READ# 3,4 ; U4(,)
23 READ# 3,5 ; U5(,)
24 READ# 3,6 ; U6(,)
25 READ# 3,7 ; U7(,)
26 READ# 3,8 ; U8(,)
27 READ# 3,9 ; U9(,)
28 READ# 3,10 ; U0(,)
29 ASSIGN# 3 TO *
30 ASSIGN# 4 TO "DATA4"
31 READ# 4,1 ; M1(,)
32 READ# 4,2 ; M2(,)
33 READ# 4,3 ; M3(,)
34 READ# 4,4 ; M4(,)
35 READ# 4,5 ; M5(,)
36 READ# 4,6 ; M6(,)
37 READ# 4,7 ; M7(,)
38 READ# 4,8 ; M8(,)
39 READ# 4,9 ; M9(,)
40 READ# 4,10 ; M0(,)
41 ASSIGN# 4 TO *
42 BEEP 100,500 @ CLEAR @ DISP USING "7/,10X,11A" ; "CHANGE TAPE" @ PAUSE
43 G9=9 @ CLEAR @ DISP USING "4/,X,30A,2/" ; "DON'T BOTHER ME, I'M THINKING!"
44 FOR L=1 TO 5 @ DISP USING "10X,4A,D" ; "L = ",L ! KW Indicator
47 IF L=1 THEN CREATE "NiCd-1",G9,768 ELSE GOTO 49
48 ASSIGN# 9 TO "NiCd-1" @ GOTO 64
49 IF L=2 THEN CREATE "NiCd-2",G9,768 ELSE GOTO 51
50 ASSIGN# 9 TO "NiCd-2" @ GOTO 64
51 IF L=3 THEN CREATE "NiCd-3",G9,768 ELSE GOTO 53
52 ASSIGN# 9 TO "NiCd-3" @ GOTO 64
53 IF L=4 THEN CREATE "NiCd-4",G9,768 ELSE GOTO 55
54 ASSIGN# 9 TO "NiCd-4" @ GOTO 64
55 IF L=5 THEN CREATE "NiCd-5",G9,768
56 ASSIGN# 9 TO "NiCd-5" @ GOTO 64
64 IF L<=4 THEN G1=1 ELSE G1=2 ! G1=1 FOR LEO,2 FOR GEO
65 G2=1 ! G2=1 FOR NiCd,2 FOR NiH2,3 FOR H2O2
66 IF L=5 THEN P0=25000 @ N2=12 @ GOTO 69
67 IF L=4 THEN P0=250000 @ N2=24 ELSE P0=25000*CEIL((L/1.5)^2) @ N2=12
69 P1=P0/10
75 IF L=5 THEN H0=35786 ELSE H0=444 ! H
76 IF L=5 THEN K0=.24 ELSE K0=.949 ! Kot
77 K5=1 ! Kot
```

```
78 IF L=5 THEN L1=5 ELSE L1=30 ! Yt
79 N=6 ! Number of Sides
80 N1=.833 ! Nss
81 N5=.935 ! Nsa
82 N6=.932 ! NL
83 IF L=5 THEN N8=1 ELSE N8=4 ! Nr
84 Q(3)=N2/N ! Length Factor
85 IF L=5 THEN S5(1)=0 ELSE S5(1)=.1 ! Spares Factor
86 T2,T5=.025 ! te
87 T3=283 ! Top
88 V0=128.8 ! Vr
95 FOR I=1 TO L @ READ W(1),W(2),W(3),W(4),W(5),W(6),W(7)@ NEXT I @ RESTORE 506
96 DATA .5,.35,.2,.4,.4,.5,.5
97 DATA .4,.35,.2,.35,.35,.45,.45
98 DAA .3,.35,.2,.3,.3,.4,.4
99 DATA .25,.2,.2,.25,.25,.35,.35
100 DATA .5,.35,.2,.4,.4,.5,.5
150 T0=.0000027645*(6375+H0)^(3/2)
200 N0=8766*K0*L1/T0
300 DEG @ T1=T0/180*(90-ACS(6375/(6375+H0)))+T2
395 P6=P0/N6+P1/N1
400 C0=P6*T1/V0
410 D,K,P=0
450 IF K=0 THEN 500
460 N8=CEIL(N0/L2/5840)
470 L0=N0/N8/5840
480 GOTO 503
500 L0,L2=N0/N8/5840
503 FOR I=1 TO 4
504 READ T(I)
505 NEXT I
506 DATA 253,273,293,313
507 B=T3
510 E=283
512 Q(1),Q(2)=0
513 C=L0
515 GOSUB 7000
537 FOR I=1 TO 4
539 FOR J=1 TO 14
541 A5(I,J)=O0(I,J)
543 B5(I,J)=O1(I,J)
545 NEXT J
547 NEXT I
550 GOSUB 9000
552 D9=Z9
553 IF D9>.6 THEN D9=.6
600 E0=C0/N2
625 C9=0
650 K1,K2=.891^(L0/L2)
655 C9=C9+1
700 IF D=0 THEN GOSUB 4900 ELSE C1=CEIL(E0/K1/D9/5)*5
800 I0=CEIL(E0/T1*1000)/1000
801 E0=I0*T1
850 D0=E0/C1/K1
853 IF C9=11 THEN 875
855 C=D0
860 GOSUB 7000
861 IF C9>1 THEN 868
862 FOR I=1 TO 4
863 FOR J=1 TO 14
864 A5(I,J)=O1(I,15-J)
865 B5(I,J)=O0(I,15-J)
```

```
866 NEXT J
867 NEXT I
868 GOSUB 9000
869 L9=Z9
871 IF C9=10 THEN L2=(L2+L9)/2 @ GOTO 650
872 IF L2#L9 THEN L2=L9 @ GOTO 650
875 IF P=0 THEN 901
880 N8=CEIL(N0/L2/5840)
885 L9=N0/N8/5840
890 IF L0#L9 THEN L0=L9 @ GOTO 513
901 FOR I=1 TO 5
902 READ S(I)
904 NEXT I
906 DATA 253,273,283,293,313
908 FOR J=1 TO 4
912 READ T(J)
914 NEXT J
915 DATA .1,.5,1,2
916 A=T3
918 B=I0/C1/K1
920 C=D0
924 E=.75
957 GOSUB 7000
988 GOSUB 7500
989 GOSUB 8000
990 V1=FLOOR(Z*K2*10000)/10000
1600 N3=CEIL(V0/V1)
1650 V4=N3*V1
1700 N4=N2*N3
1800 FOR I=1 TO 14
1805 READ T(I)
1807 READ S(I)
1810 NEXT I
1815 DATA 253,1.4613,258,1.46,263,1.4575,268,1.4538,272.25,1.4488,275.5,1.4438,277.5,1.44
1820 DATA 283,1.4288,288,1.4163,293,1.4038,298,1.3888,303,1.3738,308,1.3575,313,1.3425
1821 IF T3>=313 THEN V2=S(14)-(S(13)-S(14))^2/(S(12)-S(13))*(T3-T(14))/(T(14)-T(13)) @ GOTO 1870
1822 IF T3<=253 THEN V2=S(1)+(S(1)-S(2))^2/(S(2)-S(3))*(T(1)-T3)/(T(2)-T(1)) @ GOTO 1870
1825 IF T3<283 THEN 1850
1830 J=15
1835 J=J-1
1840 IF T3<T(J) THEN 1835
1845 V2=S(J)-(T3-T(J))/(T(J+1)-T(J))*(S(J)-S(J+1)) @ GOTO 1870
1850 J=0
1855 J=J+1
1860 IF T3>T(J) THEN 1855
1865 V2=S(J)+(T(J)-T3)/(T(J)-T(J-1))*(S(J-1)-S(J))
1870 V2=K2*V2
1900 Q0=CEIL(I0*(V2-V1)*N4)
2000 P2=V1*I0
2100 P3=P2*N4
2201 FOR I=1 TO 4
2202 READ T(I)
2203 NEXT I
2204 DATA .2083,.3125,.4688,.6063
2207 FOR I=1 TO 4
2208 FOR J=1 TO 14
2209 A5(I,J)=O2(I,J)
2210 B5(I,J)=O3(I,J)
2211 NEXT J
2212 NEXT I
2231 B=P2/C1/K1
2234 C=T3
```

```
2235 E=.4167
2260 GOSUB 7000 @ GOSUB 9000
2270 R0=Z9
2275 IF R0<1.0045 THEN R0=1.0045
2280 C4=1-D0+R0*D0
2300 T4=T0-T1-T5
2410 FOR I=1 TO 5
2411 READ S(I)
2412 NEXT I
2413 DATA 253,273,283,293,313
2420 FOR J=1 TO 4
2421 READ T(J)
2422 NEXT J
2423 DATA .05,.1,.2,.5
2425 I1=CEIL(R0*E0/T4*1000)/1000
2429 A=T3
2430 B=I1/C1/K1
2431 C=C4
2432 E=.15
2434 Q(2)=1
2436 GOSUB 7000
2440 GOSUB 7500
2442 GOSUB 8000
2444 V3=CEIL(Z/K2*10000)/10000
2445 T6=R0*E0/I1
2500 P4=I1*V3
2600 N7=P2*T1/P4/T6
2700 P5=P4*N4/N5
2800 N0=CEIL(.0205*P5)
2900 Q1=CEIL(P4*N4-(P3+Q0)*T1/T6)
3000 Q2=CEIL(MAX(Q0/2,Q1))
3100 W1=CEIL(Q2/(.000000004716*K5*(T3^4-255^4)))
4000 ! WEIGHTS & VOLUMES
4005 IF C1>=6 AND C1<=9 THEN S0(1)=5.4 @ S1(1)=2.1
4010 IF C1>=10 AND C1<=30 THEN S0(1)=7.6 @ S1(1)=2.3
4015 IF C1>=31 AND C1<=60 THEN S0(1)=12.7 @ S1(1)=3.3
4020 IF C1>=61 AND C1<=135 THEN S0(1)=18.2 @ S1(1)=3.9
4025 IF C1>=136 AND C1<=300 THEN S0(1)=27.8 @ S1(1)=5.7
4028 IF C1>=301 THEN S0(1)=42.5 @ S1(1)=8.3
4030 S2(1)=INT(11.26*(-4.074+12.98*C1)/S0(1)/S1(1)+.5)/10
4035 S2(2)=INT(13.4*S2(1)+.5)/10
4040 S0(6)=457
4045 S0(5)=INT(S0(6)*SIN(180/N)*10+.5)/10
4050 U=2*CEIL(N3/2/(S0(5)-2*S2(2)*TAN(180/N))*2.2*1.402*S1(1))
4051 U1=INT(N3/U*100+.5)/100
4055 S4(1)=.05685+.03941*C1
4060 S4(2)=1.037*N3/U*S4(1)+.03*I0
4065 S4(3)=.02*N3
4070 S4(4)=24.95
4075 S4(5)=1.012*(U*S4(2)+S4(3)+S4(4))+.2*I0+.0096*Q2/N2
4080 S4(6)=INT(14*S4(5)+.5)/1000
4100 S3(1)=INT(S0(1)*S1(1)*S2(1)+.5)
4105 S1(2)=INT(1.402*S1(1)*CEIL(N3/U)*10+.5)/10
4110 S1(3)=INT(1.402*S1(1)*FLOOR(N3/U)*10+.5)/10
4115 S0(2)=INT(1.306*S0(1)*10+.5)/10
4120 S3(2)=INT(S1(2)*S0(2)*S2(2)+.5)
4125 S3(3)=INT(S1(3)*S0(2)*S2(2)+.5)
4130 S1(4)=INT(20.3*N3/I1+.5)/10
4135 S0(3)=12.7
4140 S2(3)=6.4
4145 S3(4)=INT(S1(4)*S0(3)*S2(3)+.5)
4150 S1(5)=63.5
4155 S0(4)=26.9
```

```
4160 S2(4)=16.5
4165 S3(5)=28184
4170 S1(6)=INT(12.5*(CEIL(U/2)*S0(2)+S2(4))+.5)/10
4172 S4(7)=CEIL(N2*(S4(5)+S4(6))+.015*(Q(3)*N-N2)*S1(6)*S0(5)+.5)
4175 S2(5)=INT(10.75*MAX(S2(2),S0(4))+.5)/10
4180 S3(6)=INT(S1(6)*S0(5)*S2(5)+.5)
4190 S1(7)=S1(6)*Q(3)
4200 S3(7)=INT(S1(7)*N/4*S0(5)^2*COT(180/N)+.5)
4500 !  LIFE CYCLE COSTS
4501 F0(1)=INT((.0414*C1^2+3.123*C1+700)*N4^-.1047+.5)
4505 F0(2)=INT(.34*N4+.0014*F0(1)*N4+727+.5)/1000
4510 F0(3)=INT(.25*N4+.13*N4*S4(1)+1049+.5)/1000
4515 F0(4)=INT(.705*N2*U*S4(2)+607+.5)/1000
4520 F0(5)=INT(.172*N2*(S4(5)+S4(6))+1329+.5)/1000
4525 F0(6)=INT(.32*N4+.045*S4(7)+694+.5)/1000
4530 F0(7)=INT(.039*S4(7)+60+.5)/1000
4535 K6=CEIL(14.136*S1(7))/S4(7)
4540 IF K6<1 THEN K6=1
4545 IF L=5 THEN F0(8)=INT((5.1+8.14*K6)*S4(7)+.5)/1000 @ GOTO 4550
4547 IF L#5 THEN F0(8)=INT(1.99*K6*S4(7)+.5)/1000
4550 F0(9)=INT(.011*S4(7)+.5)/1000
4555 F0=F0(2)+F0(3)+F0(4)+F0(5)+F0(6)+F0(7)+F0(8)+F0(9)
4560 F1(1)=INT(844*S4(7)^.203+.5)/1000
4565 F1(2)=INT(989*((1+S5(1))*(F0(2)+F0(3)+F0(4)+F0(5)+F0(6)))^1.064+.5)/1000
4570 F1(3)=INT(217*F1(2)^.789+.5)/1000
4575 F1(4)=INT(828*F1(2)^.397+.5)/1000
4580 F1(5)=INT(109*(F1(1)+F1(2)+F1(3)+F1(4))^1.025+.5)/1000
4585 F1(6)=INT(94*(F1(1)+F1(2)+F1(3)+F1(4)+F1(5))^.865+.5)/1000
4590 F1(7)=INT(131*(F1(1)+F1(2)+F1(3)+F1(4)+F1(5)+F1(6))^.865+.5)/1000
4595 F1=W(1)*F1(1)+W(2)*F1(2)+W(3)*F1(3)+W(4)*F1(4)+W(5)*F1(5)+W(6)*F1(6)+W(7)*F1(7)
4597 F1=INT(F1*1000+.5)/1000
4600 IF L=5 THEN F2(1),F2(2),F2(4)=0 @ F2(3)=.1*L1 @ GOTO 4635
4605 S5(2)=N8-1+N8*S5(1)
4610 S5(3)=L1*(.002*N2*U+.001*N8*CEIL(N2*U*S5(1))+.0015*(N8-1)*N2*U)
4615 F2(1)=INT(S5(2)*(F0(2)+F0(3))*1000+.5)/1000
462 F2(2)=INT(62.5*S5(3)+.5)/1000
4625 F2(3)=INT(390*S5(3)+.5)/1000
4630 F2(4)=INT(3600*S5(3)+1.99*K6*S5(2)*S4(2)*N2*U+.5)/1000
4635 F2=F2(1)+F2(2)+F2(3)+F2(4)
4640 F3=F0+F1+F2
4645 IF L=5 THEN M=23.8 ELSE M=36.25+.545*L1
4646 F4=INT(M*P5^.803+.5)/1000
4650 F5(1)=INT(5200+.0825*Q2+1.5*V1+.5)/1000
4652 F5(2)=INT(200*N2^.848+.5)/1000
4655 F=F3+F4+F5(1)+F5(2)
4660 GOSUB 5000
4670 RESTORE @ NEXT L
4675 CLEAR @ BEEP 80,999 @ DISP USING "7/,12X,5A" ; "DONE!" @ END
4900 ! C1 SUBROUTINE
4910 C1=50
4925 ! E0 SUBROUTINE
4930 E0=C1*K1*D9
4935 GOSUB 4950
4940 E0=C0/N2
4945 RETURN
4950 ! N2 SUBROUTINE
4955 N2=CEIL(C0/E0)
4960 IF N2<=4 THEN N2=4
4965 Q(3)=CEIL(N2/8)
4970 N=CEIL(N2/Q(3))
4975 RETURN
5000 ! DATA STORE SUBROUTINE
```

```
5002 IF G0=1 THEN X(1)=G9
5004 IF G0=2 THEN X(1)=G1
5006 IF G0=3 THEN X(1)=G2
5008 IF G0=4 THEN X(1)=P0
5010 IF G0>4 THEN X(1)=0
5012 X(2)=N0
5014 X(3)=T1
5016 X(4)=T6
5018 X(5)=L1
5020 X(6)=N8
5022 X(7)=P6
5024 X(8)=V0
5026 X(9)=L0
5028 X(10)=L2
5030 X(11)=K1
5032 X(12)=K2
5034 X(13)=P3
5036 X(14)=V4
5038 X(15)=N4
5040 X(16)=H2
5042 X(17)=H3
5044 X(18)=U
5046 X(19)=U1
5048 X(20)=C1
5050 X(21)=D0
5052 X(22)=E0
5054 X(23)=I0
5056 X(24)=V1
5058 X(25)=R0
5060 X(26)=C4
5062 X(27)=I1
5064 X(28)=V3
5066 X(29)=N7
5068 X(30)=T3
5069 X(31)=V2
5070 X(32)=Q0
5072 X(33)=Q1
5074 X(34)=Q2
5076 X(35)=P5
5078 X(36)=W0
5080 X(37)=W1
5082 X(38)=K6
5084 X(39)=S4(1)
5086 X(40)=S4(2)
5088 X(41)=S4(3)
5090 X(42)=S4(4)
5092 X(43)=S4(5)
5094 X(44)=S4(6)
5096 X(45)=S4(7)
5098 X(46)=S0(1)
5100 X(47)=S1(1)
5102 X(48)=S2(1)
5104 X(49)=S1(2)
5106 X(50)=S0(2)
5108 X(51)=S2(2)
5110 X(52)=S1(3)
5112 X(53)=S0(2)
5114 X(54)=S2(2)
5116 X(55)=S1(4)
5118 X(56)=S0(3)
5120 X(57)=S2(3)
5122 X(58)=S1(5)
```

```
5124 X(59)=S0(4)
5126 X(60)=S2(4)
5128 X(61)=S1(6)
5130 X(62)=S0(5)
5132 X(63)=S2(5)
5134 X(64)=S1(7)
5136 X(65)=S0(6)
5138 X(66)=S0(5)
5140 X(67)=S3(1)
5142 X(68)=S3(2)
5144 X(69)=S3(3)
5146 X(70)=S3(4)
5148 X(71)=S3(5)
5150 X(72)=S3(6)
5152 X(73)=S3(7)
5154 X(74)=F1
5156 X(75)=F0
5158 X(76)=F0(1)
5160 X(77)=F0(2)
5162 X(78)=F0(3)
5164 X(79)=F0(4)
5166 X(80)=F0(5)
5168 X(81)=F0(6)
5170 X(82)=F0(7)
5172 X(83)=F0(8)
5174 X(84)=F0(9)
5176 X(85)=F2
5178 X(86)=F2(1)
5180 X(87)=F2(2)
5182 X(88)=F2(3)
5184 X(89)=F2(4)
5186 X(90)=F3
5188 X(91)=F4
5190 X(92)=F5(1)
5192 X(93)=F5(2)
5194 X(94)=F
5196 PRINT# 9,G0 ; X()
5198 RETURN
7000 ! 2 DIMENSION SUBROUTINE
7001 B0,B1,B2,B3=0
7005 IF B>E THEN 7090
7010 B4=0
7020 B4=B4+1
7030 IF B>=T(B4) THEN 7020
7040 IF B4=1 THEN 7070
7050 B0=(T(B4)-B)/(T(B4)-T(B4-1))
7060 GOTO 7160
7070 B2=(T(B4)-B)/(T(B4+1)-T(B4))
7080 GOTO 7160
7090 B4=5
7100 B4=B4 1
7110 IF B<=T(B4) THEN 7100
7120 IF B4=4 THEN 7150
7130 B1=(B-T(B4))/(T(B4+1)-T(B4))
7140 RETURN
7150 B3=(B-T(B4))/(T(B4)-T(B4-1))
7160 RETURN
7500 ! 3rd DIMENSION SUBROUTINE
7501 A0,A1,A2,A3=0
7502 IF A>263 THEN 7545
7505 A4=0
7510 A4=A4+1
```

```
7515 IF A>=S(A4) THEN 7510
7520 IF A4=1 THEN 7535
7525 A0=(S(A4)-A)/(S(A4)-S(A4-1))
7530 RETURN
7535 A2=(S(A4)-A)/(S(A4+1)-S(A4))
7540 RETURN
7545 A4=6
7550 A4=A4-1
7555 IF A<=S(A4) THEN 7550
7560 IF A4=5 THEN 7575
7565 A1=(A-S(A4))/(S(A4+1)-S(A4))
7570 RETURN
7575 A3=(A-S(A4))/(S(A4)-S(A4-1))
7580 RETURN
8000 ! 3rd DIMENSION SUBROUTINE
8002 ON A4 GOTO 8004,8040,8058,8076,8094
8004 GOSUB 8410
8020 GOTO 8110
8040 GOSUB 8420
8056 GOTO 8110
8058 GOSUB 8430
8074 GOTO 8110
8076 GOSUB 8440
8092 GOTO 8110
8094 GOSUB 8450
8110 Z0=Z9
8111 IF A>283 THEN 8232
8112 IF A4=1 THEN 8190
8114 ON A4-1 GOTO 8118,8154,8172
8118 GOSUB 8410
8134 GOTO 8222
8154 GOSUB 8420
8170 GOTO 8222
8172 GOSUB 8430
8188 GOTO 8222
8190 GOSUB 8420
8204 Z2=Z9
8206 GOSUB 8430
8220 Z3=Z9 @ GOTO 8223
8222 Z1=Z9
8223 IF A0=0 THEN 8228
8224 Z=Z0+A0*(Z1-Z0)
8226 RETURN
8228 Z=Z0+A2*(Z0-Z2)*((Z0-Z2)/(Z2-Z3))
8230 RETURN
8232 IF A4=5 THEN 8272
8234 ON A4-2 GOTO 8236,8254
8236 GOSUB 8440
8252 GOTO 8304
8254 GOSUB 8450
8270 GOTO 8304
8272 GOSUB 8440
8286 Z2=Z9
8288 GOSUB 8430
8302 Z3=Z9 @ GOTO 8305
8304 Z1=Z9
8305 IF A1=0 THEN 8310
8306 Z=Z0-A1*(Z0-Z1)
8308 RETURN
8310 Z=Z0-A3*(Z2-Z0)*((Z2-Z0)/(Z3-Z2))
8312 RETURN
8410 IF Q(2)=1 THEN 8911
```

```
8411 FOR I=1 TO 4
8412 FOR J=1 TO 14
8413 A5(I,J)=U1(I,J)
8414 B5(I,J)=U6(I,J)
8415 NEXT J
8416 NEXT I
8417 GOSUB 9000
8418 RETURN
8420 IF Q(2)=1 THEN 8920
8421 FOR I=1 TO 4
8422 FOR J=1 TO 14
8423 A5(I,J)=U2(I,J)
8424 B5(I,J)=U7(I,J)
8425 NEXT J
8426 NEXT I
8427 GOSUB 9000
8428 RETURN
8430 IF Q(2)=1 THEN 8930
8431 FOR I=1 TO 4
8432 FOR J=1 TO 14
8433 A5(I,J)=U3(I,J)
8434 B5(I,J)=U8(I,J)
8435 NEXT J
8436 NEXT I
8437 GOSUB 9000
8438 RETURN
8440 IF Q(2)=1 THEN 8940
8441 FOR I=1 TO 4
8442 FOR J=1 TO 14
8443 A5(I,J)=U4(I,J)
8444 B5(I,J)=U9(I,J)
8445 NEXT J
8446 NEXT I
8447 GOSUB 9000
8448 RETURN
8450 IF Q(2)=1 THEN 8950
8451 FOR I=1 TO 4
8452 FOR J=1 TO 14
8453 A5(I,J)=U5(I,J)
8454 B5(I,J)=U0(I,J)
8455 NEXT J
8456 NEXT I
8457 GOSUB 9000
8458 RETURN
8911 FOR I=1 TO 4
8912 FOR J=1 TO 14
8913 A5(I,J)=H1(I,J)
8914 B5(I,J)=H6(I,J)
8915 NEXT J
8916 NEXT I
8917 GOSUB 9000
898 RETURN
8920 FOR I=1 TO 4
8921 FOR J=1 TO 14
8922 A5(I,J)=H2(I,J)
8923 B5(I,J)=H7(I,J)
8924 NEXT J
8925 NEXT I
8926 GOSUB 9000
8927 RETURN
8930 FOR I=1 TO 4
8931 FOR J=1 TO 14
8932 A5(I,J)=H3(I,J)
8933 B5(I,J)=H8(I,J)
```

```
8934 NEXT J
8935 NEXT I
8936 GOSUB 9000
8937 RETURN
8940 FOR I=1 TO 4
8941 FOR J=1 TO 14
8942 A5(I,J)=H4(I,J)
8943 B5(I,J)=H9(I,J)
8944 NEXT J
8945 NEXT I
8946 GOSUB 9000
8947 RETURN
8950 FOR I=1 TO 4
8951 FOR J=1 TO 14
8952 A5(I,J)=H5(I,J)
8953 B5(I,J)=H0(I,J)
8954 NEXT J
8955 NEXT I
8956 GOSUB 9000
8957 RETURN
9000 ! INTERPOLATION SUBROUTINE
9003 X0(1),X1(1),X2(1),X3(1)=0
9005 IF C>A5(B4,7) THEN 9036
9010 G=0
9015 G=G+1
9020 IF C>=A5(B4,G) THEN 9015
9025 X0(2)=(A5(B4,G)-C)/(A5(B4,G)-A5(B4,G-1))
9030 GOTO 9055
9036 G=15
9040 G=G-1
9045 IF C<=A5(B4,G) THEN 9040
9050 X0(1)=(C-A5(B4,G))/(A5(B4,G+1)-A5(B4,G))
9055 IF B>E THEN 9315
9060 IF B4=1 THEN 9095
9065 IF C>A5(B4-1,7) THEN 9146
9070 H=0
9075 H=H+1
9080 IF C>=A5(B4-1,H) THEN 9075
9085 X1(2)=(A5(B4-1,H)-C)/(A5(B4-1,H)-A5(B4-1,H-1))
9090 GOTO 9210
9095 IF C>A5(B4+1,7) THEN 9171
9100 H=0
9105 H=H+1
9110 IF C>=A5(B4+1,H) THEN 9105
9115 X2(2)=(A5(B4+1,H)-C)/(A5(B4+1,H)-A5(B4+1,H-1))
9120 J=0
9125 J=J+1
9130 IF C>=A5(B4+2,J) THEN 9125
9135 X3(2)=(A5(B4+2,J)-C)/(A5(B4+2,J)-A5(B4+2,J-1))
9140 GOTO 9210
9146 H=15
9150 H=H-1
9155 IF C<=A5(B4-1,H) THEN 9150
9160 X1(1)=(C-A5(B4-1,H))/(A5(B4-1,H+1)-A5(B4-1,H))
9165 GOTO 9210
9171 H=15
9175 H=H-1
9180 IF C<=A5(B4+1,H) THEN 9175
9185 X2(1)=(C-A5(B4+1,H))/(A5(B4+1,H+1)-A5(B4+1,H))
9190 J=15
9195 J=J-1
9200 IF C<=A5(B4+2,J) THEN 9195
```

```
9205 X3(1)=(C-A5(B4+2,J))/(A5(B4+2,J+1)-A5(B4+2,J))
9210 IF X0(1)=0 THEN 9225
9215 Y0=B5(B4,G)-X0(1)*(B5(B4,G)-B5(B4,G+1))
9220 GOTO 9230
9225 Y0=B5(B4,G)+X0(2)*(B5(B4,G-1)-B5(B4,G))
9230 IF B4=1 THEN 9265
9235 IF X1(1)=0 THEN 9250
9240 Y1=B5(B4-1,H)-X1(1)*(B5(B4-1,H)-B5(B4-1,H+1))
9245 GOTO 9256
9250 Y1=B5(B4-1,H)+X1(2)*(B5(B4-1,H-1)-B5(B4-1,H))
9256 Z9=Y0+B0*(Y1-Y0)
9257 RETURN
9265 IF X2(1)=0 THEN 9280
9270 Y2=B5(B4+1,H)-X2(1)*(B5(B4+1,H)-B5(B4+1,H+1))
9275 GOTO 9285
9280 Y2=B5(B4+1,H)+X2(2)*(B5(B4+1,H-1)-B5(B4+1,H))
9285 IF X3(1)=0 THEN 9300
9290 Y3=B5(B4+2,J)-X3(1)*(B5(B4+2,J)-B5(B4+2,J+1))
9295 GOTO 9305
9300 Y3=B5(B4+2,J)+X3(2)*(B5(B4+2,J-1)-B5(B4+2,J))
9305 IF Q(1)=1 THEN 9310
9306 Z9=Y0+B2*(Y0-Y2)*((Y0-Y2)/(Y2-Y3))
9307 RETURN
9310 Z9=T(B4)-(Y0-C4)/(Y2-Y0)*(T(B4+1)-T(B4))*(T(B4+1)-T(B4))/(T(B4+2)-T(B4+1))
9311 RETURN
9315 IF B4=4 THEN 9350
9320 IF C>A5(B4+1,7) THEN 9401
9325 H=0
9330 H=H+1
9335 IF C>=A5(B4+1,H) THEN 9330
9340 X1(2)=(A5(B4+1,H)-C)/(A5(B4+1,H)-A5(B4+1,H-1))
9345 GOTO 9465
9350 IF C>A5(B4-1,7) THEN 9426
9355 H=0
9360 H=H+1
9365 IF C>=A5(B4-1,H) THEN 9360
9370 X2(2)=(A5(B4-1,H)-C)/(A5(B4-1,H)-A5(B4-1,H-1))
9375 J=0
9380 J=J+1
9385 IF C>=A5(B4-2,J) THEN 9380
9390 X3(2)(A5(B4-2,J)-C)/(A5(B4-2,J)-A5(B4-2,J-1))
9395 GOTO 9465
9401 H=15
9405 H=H-1
9410 IF C<=A5(B4+1,H) THEN 9405
9415 X1(1)=(C-A5(B4+1,H))/(A5(B4+1,H+1)-A5(B4+1,H))
9420 GOTO 9465
9426 H=15
9430 H=H-1
9435 IF C<=A5(B4-1,H) THEN 9430
9440 X2(1)=(C-A5(B4-1,H))/(A5(B4-1,H+1)-A5(B4-1,H))
9445 J=15
9450 J=J-1
9455 IF C<=A5(B4-2,J) THEN 9450
9460 X3(1)=(C-A5(B4-2,J))/(A5(B4-2,J+1)-A5(B4-2,J))
9465 IF X0(1)=0 THEN 9480
9470 Y0=B5(B4,G)-X0(1)*(B5(B4,G)-B5(B4,G+1))
9475 GOTO 9485
9480 Y0=B5(B4,G)+X0(2)*(B5(B4,G-1)-B5(B4,G))
9485 IF B4=4 THEN 9520
9490 IF X1(1)=0 THEN 9505
9495 Y1=B5(B4+1,H)-X1(1)*(B5(B4+1,H)-B5(B4+1,H+1))
```

```
9500 GOTO 9511
9505 Y1=B5(B4+1,H)+X1(2)*(B5(B4+1,H-1)-B5(B4+1,H))
9511 Z9=Y0-B1*(Y0-Y1)
9512 RETURN
9520 IF X2(1)=0 THEN 9535
9525 Y2=B5(B4-1,H)-X2(1)*(B5(B4-1,H)-B5(B4-1,H+1))
9530 GOTO 9540
9535 Y2=B5(B4-1,H)+X2(2)*(B5(B4-1,H-1)-B5(B4-1,H))
9540 IF X3(1)=0 THEN 9555
9545 Y3=B5(B4-2,J)-X3(1)*(B5(B4-2,J)-B5(B4-2,J+1))
9550 GOTO 9561
9555 Y3=B5(B4-2,J)+X3(2)*(B5(B4-2,J-1)-B5(B4-2,J))
9561 Z9=Y0-B3*(Y2-Y0)*((Y2-Y0)/(Y3-Y2))
9562 RETURN
```

```
10 ! "DATA1*"
15 OPTION BASE 1
20 DIM V6(4,14),D6(4,14)
30 ! CREATE "DATA1",2,768
40 ASSIGN# 1 TO "DATA1"
50 FOR I=1 TO 4
60 FOR J=1 TO 14
70 READ D6(I,J) ! LIFE YEARS
80 NEXT J
90 NEXT I
100 PRINT# 1,1 ; D6(,)
110 FOR I=1 TO 4
120 FOR J=1 TO 14
130 READ V6(I,J) ! DOD
140 NEXT J
150 NEXT I
160 PRINT# 1,2 ; V6(,)
170 ASSIGN# 1 TO *
180 DATA 0,.6,1.25,1.7,2.2,3,4,5.1,7.75,9,9.8,10.5,11.2,11.75
190 DATA 0,.5,1,1.4,1.95,2.75,3.6,4.6,7.7,8.9,9.6,10.4,11,11.6
200 DATA 0,.4,1,1.8,2.8,4,5.6,6.8,7.75,8.5,9.1,9.65,10.3,10.9
210 DATA 0,.7,1.5,2.2,3,4,5,6.2,7,7.75,8.4,8.9,9.5,9.95
220 DATA .78,.68,.595,.55,.5075,.455,.405,.36,.255,.2,.155,.11,.055,0
230 DATA .734,.66,.6,.55,.505,.455,.41,.3675,.245,.195,.155,.1,.0525,0
240 DATA .65,.5775,.5125,.455,.4,.345,.285,.24,.2,.165,.1325,.1,.05,0
250 DATA .46,.41,.365,.33,.3,.265,.23,.19,.165,.135,.105,.075,.035,0
260 END
```

```
10 ! "DATA2*"
15 OPTION BASE 1
20 DIM V6(4,14),D6(4,14)
30 ! CREATE "DATA2",2,768
40 ASSIGN# 1 TO "DATA2"
50 FOR I=1 TO 4
60 FOR J=1 TO 14
70 READ D6(I,J) ! TEMPERATURE
80 NEXT J
90 NEXT I
100 PRINT# 1,1 ; D6(,)
110 FOR I=1 TO 4
120 FOR J=1 TO 14
130 READ V6(I,J) ! RECHARGE FRACTION
140 NEXT J
150 NEXT I
160 PRINT# 1,2 ; V6(,)
170 ASSIGN# 1 TO *
180 DATA 253,263,272.5,280,284.5,288,292,295,298,300.5,303,306.5,310,313
190 DATA 253,263,272,277,281.5,285,290.25,293.75,297.25,300,303,306,309.5,313
200 DATA 253,263,270,277.5,283,287.25,290.5,294,298,301,304.5,307.25,310,313
220 DATA 253,267,270.5,278,282.5,286.5,290,293.5,296.25,300,303,306.5,309.5,313
230 DATA 1.1475,1.15,1.155,1.1625,1.17,1.1775,1.19,1.2025,1.212,1.24,1.265,1.305,1.36,1.42
240 DATA 1.08,1.0825,1.085,1.09,1.095,1.1,1.11,1.12,1.135,1.15,1.17,1.195,1.23,1.275
250 DATA 1.0375,1.0375,1.04,1.045,1.05,1.055,1.06,1.0675,1.08,1.09,1.105,1.12,1.1375,1.16
270 DATA 1.0075,1.01,1.01,1.0125,1.015,1.0175,1.02,1.025,1.0275,1.0325,1.0375,1.045,1.0525,1.065
280 END
```

```
10 ! "DATA3*"
15 OPTION BASE 1
20 DIM D6(4,14),V6(4,14)
40 ! CREATE "DATA3",10,768
50 ASSIGN# 1 TO "DATA3"
55 FOR N=1 TO 5
60 FOR I=1 TO 4
70 FOR J=1 TO 14
80 READ D6(I,J) ! DOD
100 NEXT J
110 NEXT I
120 PRINT# 1,N ; D6(,)
130 NEXT N
140 FOR K=1 TO 5
150 FOR L=1 TO 4
160 FOR M=1 TO 14
170 READ V6(L,M) ! DISCHARGE VOLTAGE
180 NEXT M
190 NEXT L
200 PRINT# 1,K+5 ; V6(,)
210 NEXT K
220 ASSIGN# 1 TO *
230 DATA 0,.055,.1,.145,.23,1,1.16,1.27,1.37,1.45,1.505,1.54,1.585,1.63
240 DATA 0,.05,.11,.17,.27,1,1.1,1.2,1.28,1.355,1.4,1.45,1.48,1.51
250 DATA 0,.05,.1,.2,.4,.8,.97,1.1,1.2,1.27,1.33,1.375,1.4,1.44
260 DATA 0,.085,.13,.18,13,.7,.85,.96,1.08,1.16,1.22,1.265,1.285,1.315
270 DATA 0,.05,.09,.15,.3,1.05,1.15,1.22,1.28,1.335,1.38,1.425,1.455,1.53
280 DATA 0,.055,.1,.2,.31,.85,1,1.1,1.18,1.24,1.28,1.34,1.38,1.41
290 DATA 0,.05,.115,.2,.4,.8,.95,1.05,1.15,1.2,1.235,1.265,1.3,1.35
300 DATA 0,.09,.14,.2,.4,.6,.7,.8,.91,1,1.05,1.1,1.15,1.23
310 DATA 0,.06,.1,.15,.25,.9,1.1,1.15,1.2,1.25,1.285,1.3,1.35,1.43
320 DATA 0,.05,.1,.15,.2,.4,.8,1,1.1,1.17,1.21,1.245,1.275,1.32
330 DATA 0,.05,.1,.15,.2,.4,.6,.8,.9,1,1.1,1.15,1.19,1.26
340 DATA 0,.05,.1,.15,.2,.35,.7,.765,.82,.9,.95,1,1.07,1.15
350 DATA 0,.03,.07,.14,.23,.9,1,1.1,1.16,1.2,1.23,1.245,1.26,1.29
360 DATA 0,.03,.08,.14,.21,.35,.7,.86,.97,1.04,1.095,1.125,1.145,1.19
370 DATA 0,.04,.08,.15,.224,.4,.65,.76,.84,.92,.99,1.04,1.07,1.135
380 DATA 0,.05,.1,.15,.2,.35,.55,.7,.8,.86,.905,.94,.99,1.035
390 DATA 0,.05,.1,.17,.25,.4,.46,.5,.53,.54,.545,.55,.56,.565
400 DATA 0,.03,.07,.15,.22,.285,.395,.45,.48,.5,.52,.53,.535,.54
410 DATA 0,.03,.07,.15,.23,.3,.365,.415,.445,.465,.48,.49,.5,.515
420 DATA 0,.03,.06,.1,.15,.25,.3,.335,.365,.39,.405,.425,.44,.47
430 DATA 1.44,1.4,1.37,1.355,1.345,1.31,1.295,1.26,1.18,1.07,.9,.7,.37,0
440 DATA 1.4,1.35,1.31,1.29,1.27,1.25,1.24,1.2,1.15,1.08,1,.8,.5,0
450 DATA 1.34,1.3,1.27,1.235,1.21,1.195,1.18,1.135,1.07,.99,.885,.75,.6,0
460 DATA 1.29,1.2,1.17,1.15,1.135,1.105,1.085,1.045,.975,.9,.8,.6,.4,0
470 DATA 1.42,1.38,1.35,1.325,1.315,1.28,1.27,1.245,1.195,1.11,1,.8,.6,0
480 DATA 1.38,1.32,1.29,1.255,1.245,1.22,1.205,1.18,1.135,1.08,1,.8,.5,0
490 DATA 1.32,1.275,1.24,1.21,1.19,1.165,1.14,1.1,1.03,.965,.9,.8,.6,0
500 DATA 1.27,1.17,1.13,1.125,1.21,1.085,1.075,1.055,1.01,.945,.89,.79,.6,0
510 DATA 1.4,1.345,1.32,1.3,1.29,1.26,1.25,1.24,1.22,1.17,1.09,1,.55,0
520 DATA 1.36,1.3,1.27,1.25,1.235,1.21,1.18,1.16,1.13,1.07,1,.84,.675,0
530 DATA 1.3,1.25,1.22,1.2,1.19,1.16,1.15,1.13,1.11,1.05,.95,.83,.6,0
540 DATA 1.25,1.18,1.135,1.11,1.1,1.08,1.04,1.025,1,.94,.88,.75,.45,0
550 DATA 1.375,1.335,1.3,1.265,1.245,1.21,1.2,1.17,1.12,1.03,.87,.65,.43,0
560 DATA 1.33,1.29,1.25,1.22,1.2,1.18,1.15,1.13,1.1,1.05,.95,.79,.6,0
570 DATA 1.275,1.235,1.205,1.17,1.145,1.125,1.1,1.08,1.05,.99,.9,.77,.62,0
580 DATA 1.225,1.15,1.1,1.075,1.055,1.03,.995,.95,.885,.81,.7,.57,.3,0
590 DATA 1.305,1.24,1.19,1.15,1.12,1.09,1.07,1.03,.98,.9,.8,.6,.35,0
600 DATA 1.27,1.23,1.18,1.12,1.09,1.07,1.04,1.005,.965,.91,.75,.5,.25,0
610 DATA 1.215,1.16,1.11.06,1.03,1.005,.985,.95,.9,.84,.75,.55,.3,0
620 DATA 1.165,1.09,1.055,1.02,.99,.955,.935,.915,.875,.825,.75,.62,.4,0
630 END
```

```
10 ! "DATA4*"
15 OPTION BASE 1
20 DIM D6(4,14),V6(4,14)
30 ! CREATE "DATA4",10,768
40 ASSIGN# 1 TO "DATA4"
50 FOR H=1 TO 5
60 FOR I=1 TO 4
70 FOR J=1 TO 14
80 READ D6(I,J) ! CHARGE THRU-PUT
90 NEXT J
100 NEXT I
110 PRINT# 1,H ; D6(,)
120 NEXT H
130 FOR K=1 TO 5
140 FOR L=1 TO 4
150 FOR M=1 TO 14
160 READ V6(L,M) ! CHARGE VOLTAGE
170 NEXT M
180 NEXT L
190 PRINT# 1,K+5 ; V6(,)
200 NEXT K
210 ASSIGN# 1 TO *
221 DATA .1,.36,.52,.65,.75,.84,.9,1,1.1,1.2,1.275,1.35,1.43,1.5
231 DATA .1,.36,.5,.75,.84,.95,1.04,1.15,1.2,1.27,1.35,1.4,1.45,1.5
241 DATA .1,.32,.5,.75,.835,.91,.97,1.05,1.13,1.2,1.28,1.34,1.41,1.5
251 DATA .1,.25,.4,.66,.77,.87,.96,1.06,1.14,1.22,1.28,1.35,1.43,1.5
261 DATA .1,.18,.28,.365,.45,.54,.68,.8,.9,1.02,1.12,1.21,1.32,1.5
271 DATA .1,.22,.35,.49,.6,.7,.82,.925,1.02,1.1,1.18,1.3,1.405,1.5
281 DATA .1,.18,.28,.39,.52,.65,.76,.875,1.09,1.185,1.26,1.32,1.4,1.5
291 DATA .1,.24,.43,.59,.71,.83,1.01,1.08,1.15,1.21,.275,1.35,1.41,1.5
301 DATA .1,.185,.285,.385,.535,.68,.85,.94,1.01,1.09,1.18,1.29,1.4,1.5
311 DATA .1,.2,.305,.4,.5,.615,.79,.97,1.11,1.19,1.27,1.36,1.44,1.5
321 DATA .1,.23,.34,.42,.51,.66,.8,.9,1.005,1.16,1.27,1.35,1.4,1.5
331 DATA .1,.25,.34,.43,.67,.81,.88,.95,1.1,1.18,1.26,1.33,1.39,1.5
341 DATA .1,.19,.3,.39,.535,.68,.78,.9,1.01,1.11,1.21,1.32,1.42,1.5
351 DATA .1,.21,.31,.39,.5,.62,.865,.975,1.1,1.23,1.33,1.38,1.44,1.5
361 DATA .1,.21,.32,.46,.57,.7,.855,.95,1.02,1.13,1.22,1.31,1.4,1.5
371 DATA .1,.19,.32,.42,.58,.765,.915,1.045,1.155,1.215,1.28,1.35,1.41,1.5
381 DATA .1,.16,.23,.32,.41,.49,.6,.75,.86,.97,1.11,1.25,1.37,1.5
391 DATA .1,.185,295,.38,.49,.63,.71,.8,.95,1.08,1.2,1.3,1.4,1.5
401 DATA .1,.195,.28,.36,.49,.61,.72,.84,1.01,1.14,1.25,1.33,1.42,1.5
411 DATA .1,.2,.27,.36,.5,.775,.9,1.03,1.13,1.29,1.35,1.4,1.45,1.5
421 DATA 1.3575,1.395,1.41,1.415,1.42,1.425,1.43,1.445,1.465,1.49,1.505,1.5175,1.5275,1.535
431 DATA 1.39,1.425,1.44,1.455,1.465,1.48,1.5,1.535,1.55,1.565,1.5725,1.575,1.575,1.5725
441 DATA 1.405,1.44,1.4575,1.4725,1.485,1.5,1.52,1.555,1.585,1.605,1.6125,1.6125,1.605,1.59
451 DATA 1.4175,1.4525,1.48,1.525,1.555,1.59,1.645,1.7075,1.7375,1.75,1.75,1.7425,1.725,1.705
461 DATA 1.3375,1.355,1.37,1.38,1.385,1.39,1.395,1.4,1.405,1.42,1.435,1.45,1.4625,1.4775
471 DATA 1.3625,1.3825,1.3975,1.41,1.415,1.42,1.4275,1.44,1.455,1.475,1.49,1.5025,1.51,1.5075
481 DATA 1.375,1.39,1.405,1.4175,1.4275,1.4325,1.44,1.455,1.51,1.53,1.5375,1.54,1.5375,1.525
491 DATA 1.3875,1.42,1.45,1.465,1.485,1.52,1.6,1.625,1.64,1.6475,1.65,1.6475,1.64,1.62
501 DATA 1.3325,1.35,1.365,1.375,1.385,1.39,1.395,1.4,1.4075,1.415,1.425,1.4375,1.4475,1.4525
511 DATA 1.3525,1.37,1.385,1.395,1.4025,1.4075,1.415,1.43,1.45,1.465,1.475,1.4825,1.485,1.4825
521 DATA 1.365,1.39,1.405,1.4125,1.4175,1.425,1.4325,1.4425,1.46,1.495,1.5125,1.5175,1.5175,1.505
531 DATA 1.375,1.41,1.425,1.435,1.455,1.475,1.49,1.51,1.565,1.585,1.5975,1.6,1.5975,1.5825
541 DATA 1.325,1.345,1.3625,1.37,1.38,1.385,1.3875,1.39,1.395,1.4025,1.41,1.4175,1.425,1.4275
551 DATA 1.3425,1.365,1.38,1.3875,1.3975,1.4025,1.41,1.415,1.425,1.44,1.4525,1.4575,1.6,1.455
561 DATA 1.355,1.38,1.395,1.4075,1.415,1.42,1.425,1.4325,1.44,1.46,1.48,1.4925,1.495,1.4875
571 DATA 1.365,1.385,1.41,1.42,1.4325,1.4425,1.4575,1.485,1.5225,1.54,1.55,1.555,1.5525,1.54
581 DATA 1.3,1.315,1.3275,1.3375,1.345,1.35,1.355,1.36,1.3625,1.3625,1.365,1.365,1.365,1.365
591 DATA 1.31,1.33,1.3475,1.355,1.36,1.365,1.3675,1.37,1.375,1.375,1.3775,1.38,1.3825,1.3825
601 DATA 1.32,1.34,1.355,1.3625,1.37,1.375,1.38,1.3825,1.39,1.395,1.4,1.405,1.41,1.41
611 DATA 1.33,1.3525,1.365,1.375,1.3825,1.3925,1.3975,1.41,1.4225,1.45,1.4575,1.46,1.4575,1.4525
621 END
```

```
1 !  "N1H2","FH",2
2 OPTION BASE 1
3 COM G,X(96) ,INTEGER B9,C9,C0,G9,L,N,I,J,U,Q(3),A4,B4 ,SHORT T(14),S(14),K0,K1,K2,K5,K6
4 SHORT A,B,C,E,H,Y,Z,A0,A1,A2,A3,A5(4,14),B0,B1,B2,B3,B5(4,14),C0,C1,C2,C3,C4,D0,E0,H0,I0,I1
5 SHORT L0,L1,L2,L9,M0(4,14),M1(4,14),M2(4,14),M3(4,14),M4(4,14),M5(4,14),M6(4,14),M7(4,14)
6 SHORT M8(4,14),M9(4,14),N0,N1,N2,N3,N4,N5,N6,N7,N8,O0(4,14),O1(4,14),O2(4,14),O3(4,14),P0,P1,P
7 SHORT P2,P3,P4,P5,P6,Q0,Q1,Q2,R0,R1,R9,S0(6),S1(7),S2(5),S3(7),S4(7),S5(3),T0,T1,T2,T3,T4,T5,T6
8 SHORT U0(4,14),U1(4,14),U2(4,14),U3(4,14),U4(4,14),U5(4,14),U6(4,14),U7(4,14),U8(4,14),U9(4,14)
9 SHORT V0,V1,V2,V3,V4,W(7),W0,W1,X0(2),X1(2),X2(2),X3(2),Y0,Y1,Y2,Y3,Z0,Z1,Z2,Z3,Z9,F0(9),F1(7)
10 ASSIGN# 1 TO "DATA5"
11 READ# 1,1 ; O0(,)
12 READ# 1,2 ; O1(,)
13 ASSIGN# 1 TO *
14 ASSIGN# 2 TO "DATA6"
15 READ# 2,1 ; O2(,)
16 READ# 2,2 ; O3(,)
17 ASSIGN# 2 TO *
18 ASSIGN# 3 TO "DATA7"
19 READ# 3,1 ; U1(,)
20 READ# 3,2 ; U2(,)
21 READ# 3,3 ; U3(,)
22 READ# 3,4 ; U4(,)
23 READ# 3,5 ; U5(,)
24 READ# 3,6 ; U6(,)
25 READ# 3,7 ; U7(,)
26 READ# 3,8 ; U8(,)
27 READ# 3,9 ; U9(,)
28 READ# 3,10 ; U0(,)
29 ASSIGN# 3 TO *
30 ASSIGN# 4 TO "DATA8"
31 READ# 4,1 ; M1(,)
32 READ# 4,2 ; M2(,)
33 READ# 4,3 ; M3(,)
34 READ# 4,4 ; M4(,)
35 READ# 4,5 ; M5(,)
36 READ# 4,6 ; M6(,)
37 READ# 4,7 ; M7(,)
38 READ# 4,8 ; M8(,)
39 READ# 4,9 ; M9(,)
40 READ# 4,10 ; M0(,)
41 ASSIGN# 4 TO *
42 BEEP 100,500 @ CLEAR @ DISP USING "7/,10X,11A" ; "CHANGE TAPE" @ PAUSE
43 G9=9 @ CLEAR @ DISP USING "4/,X,30A,2/" ; "DON'T BOTHER ME, I'M THINKING!"
44 FOR L=1 TO 5 @ DISP USING "10X,4A,D" ; "L = ",L ! KW Indicator
47 IF L=1 THEN CREATE "N1H2-1",G9,768 ELSE GOTO 49
48 ASSIGN# 9 TO "N1H2-1" @ GOTO 64
49 IF L=2 THEN CREATE "N1H2-2",G9,768 ELSE GOTO 51
50 ASSIGN# 9 TO "N1H2-2" @ GOTO 64
51 IF L=3 THEN CREATE "N1H2-3",G9,768 ELSE GOTO 53
52 ASSIGN# 9 TO "N1H2-3" @ GOTO 64
53 IF L=4 THEN CREATE "N1H2-4",G9,768 ELSE GOTO 55
54 ASSIGN# 9 TO "N1H2-4" @ GOTO 64
55 IF L=5 THEN CREATE "N1H2-5",G9,768
56 ASSIGN# 9 TO "N1H2-5" @ GOTO 64
64 IF L<=4 THEN G1=1 ELSE G1=2 ! G1=1 FOR LEO,2 FOR GEO
65 G2=2 ! G2=1 FOR NiCd,2 FOR N1H2,3 FOR H2O2
66 IF L=5 THEN P0=25000 @ N2=12 @ GOTO 69
67 IF L=4 THEN P0=250000 @ N2=24 ELSE P0=25000*CEIL((L/1.5)^2) @ N2=12
69 P1=P0/10
75 IF L=5 THEN H0=35786 ELSE H0=444 ! H
76 IF L=5 THEN K0=.24 ELSE K0=.949 ! Kot
77 K5=1 ! Kot
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78 IF L=5 THEN L1=5 ELSE L1=30 ! Yt
79 N=6 ! Number of Sides
80 N1=.833 ! Nss
81 N5=.935 ! Nsa
82 N6=.932 ! NL
83 IF L=5 THEN N8=1 ELSE N8=4 ! Nr
84 Q(3)=N2/N ! Length Factor
85 IF L=5 THEN S5(1)=0 ELSE S5(1)=.1 ! Spares Factor
86 T2,T5=.025 ! te
87 T3=283 ! Top
88 V0=128.8 ! Vr
95 FOR I=1 TO L @ READ W(1),W(2),W(3),W(4),W(5),W(6),W(7)@ NEXT I @ RESTORE 506
96 DATA .5,.35,.2,.4,.4,.5,.5
97 DATA .4,.35,.2,.35,.35,.45,.45
98 DAA .3,.35,.2,.3,.3,.4,.4
99 DATA .25,.2,.2,.25,.25,.35,.35
100 DATA .5,.35,.2,.4,.4,.5,.5
150 T0=.0000027645*(6375+H0)^(3/2)
200 H0=8766*K0*L1/T0
300 DEG @ T1=T0/180*(90-ACS(6375/(6375+H0)))+T2
395 P6=P0/N6+P1/N1
400 C0=P6*T1/V0
410 D,K,P=0
450 IF K=0 THEN 500
460 N8=CEIL(H0/L2/5840)
470 L0=H0/N8/5840
480 GOTO 503
500 L0,L2=H0/N8/5840
503 FOR I=1 TO 4
504 READ T(I)
505 NEXT I
506 DATA 253,273,293,313
507 B=T3
510 E=283
512 Q(1),Q(2)=0
513 C=L0
515 GOSUB 7000
537 FOR I=1 TO 4
539 FOR J=1 TO 14
541 A5(I,J)=O0(I,J)
543 B5(I,J)=O1(I,J)
545 NEXT J
547 NEXT I
550 GOSUB 9000
552 D9=Z9
553 IF T3<=293 AND D9>.85 THEN D9=.85
554 IF T3>293 AND D9>.75 THEN D9=.75
600 E0=C0/N2
625 C9=0
650 K1,K2=.891^(L0/L2)
655 C9=C9+1
700 IF D=0 THEN GOSUB 4900 ELSE C1=CEIL(E0/K1/D9/5)*5
800 I0=CEIL(E0/T1*1000)/1000
801 E0=I0*T1
850 D0=E0/C1/K1
853 IF C9=11 THEN 875
855 C=D0
860 GOSUB 7000
861 IF C9>1 THEN 868
862 FOR I=1 TO 4
863 FOR J=1 TO 14
864 A5(I,J)=O1(I,15-J)
```

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865 B5(I,J)=O0(I,15-J)
866 NEXT J
867 NEXT I
868 GOSUB 9000
869 L9=Z9
871 IF C9=10 THEN L2=(L2+L9)/2 @ GOTO 650
872 IF L2#L9 THEN L2=L9 @ GOTO 650
875 IF P=0 THEN 901
880 N8=CEIL(N0/L2/5840)
885 L9=N0/N8/5840
890 IF L0#L9 THEN L0=L9 @ GOTO 513
901 FOR I=1 TO 5
902 READ S(I)
904 NEXT I
906 DATA 253,273,283,293,313
908 FOR J=1 TO 4
912 READ T(J)
914 NEXT J
915 DATA .1,.5,1,2
916 A=T3
918 B=10/C1/K1
920 C=D0
924 E=.75
957 GOSUB 7000
988 GOSUB 7500
989 GOSUB 8000
990 V1=FLOOR(Z*K2*10000)/10000
1600 N3=CEIL(V0/V1)
1650 V4=N3*V1
1700 N4=N2*N3
1800 FOR I=1 TO 14
1805 READ T(I)
1807 READ S(I)
1810 NEXT I
1815 DATA 253,1.483,258,1.4816,263,1.4791,268,1.4754,272.25,1.4703,275.5,1.4652,277.5,1.4614
1820 DATA 283,1.45,288,1.4373,293,1.4246,298,1.4094,303,1.3942,308,1.3777,313,1.3618
1821 IF T3>=313 THEN V2=S(14)-(S(13)-S(14))^2/(S(12)-S(13))*(T3-T(14))/(T(14)-T(13)) @ GOTO 1870
1822 IF T3<=253 THEN V2=S(1)+(S(1)-S(2))^2/(S(2)-S(3))*(T(1)-T3)/(T(2)-T(1)) @ GOTO 1870
1825 IF T3<283 THEN 1850
1830 J=15
1835 J=J-1
1840 IF T3<T(J) THEN 1835
1845 V2=S(J)-(T3-T(J))/(T(J+1)-T(J))*(S(J)-S(J+1)) @ GOTO 1870
1850 J=0
1855 J=J+1
1860 IF T3>T(J) THEN 1855
1865 V2=S(J)+(T(J)-T3)/(T(J)-T(J-1))*(S(J-1)-S(J))
1870 V2=K2*V2
1900 Q0=CEIL(10*(V2-V1)*N4)
2000 P2=V1*10
2100 P3=P2*N4
2195 T4,T6=T0-T1-T5
2201 FOR I=1 TO 4
2202 READ T(I)
2203 NEXT I
2204 DATA .054,.15,.326,1
2207 FOR I=1 TO 4
2208 FOR J=1 TO 14
2209 A5(I,J)=O2(I,J)
2210 B5(I,J)=O3(I,J)
2211 NEXT J
2212 NEXT I
```

```
2215 B9=0
2216 R1=D0
2217 B9=B9+1
2218 R0=R1/D0
2219 I1=CEIL(R0*E0/T6*1000)/1000
2230 IF B9=11 THEN 2280
2231 B=I1/C1/K1
2232 IF B>1 THEN I1=.999*C1*K1 @ T6=R0*E0/I1 @ B=I1/C1/K1
2233 IF B<.054 THEN I1=.055*C1*K1 @ T6=R0*E0/I1 @ B=I1/C1/K1
2234 C=1.475
2235 E=.2
2260 GOSUB 7000 @ GOSUB 9000
2270 IF Z9>D0 THEN GOSUB 6000 ELSE GOSUB 6500
2273 I B9=10 THEN R1=(R1+R9)/2 @ GOTO 2217
2274 IF R1#R9 THEN R1=R9 @ GOTO 2217
2280 C4=1-D0+R0*D0
2300 IF L=5 THEN I1=I1*T6/T4
2410 FOR I=1 TO 5
2411 READ S(I)
2412 NEXT I
2413 DATA 253,273,283,293,313
2420 FOR J=1 TO 4
2421 READ T(J)
2422 NEXT J
2423 DATA .05,.1,.2,.5
2429 A=T3
2430 B=I1/C1/K1
2431 C=C4
2432 E=.15
2434 Q(2)=1
2436 GOSUB 7000
2440 GOSUB 7500
2442 GOSUB 8000
2444 V3=CEIL(Z/K2*10000)/10000
2445 IF L#5 THEN T6=R0*E0/I1
2446 IF L=5 THEN T=T4 ELSE T=T6
2500 P4=I1*V3
2600 N7=P2*T1/P4/T
2700 P5=P4*N4/N5
2800 W0=CEIL(.0205*P5)
2900 Q1=CEIL(P4*N4-(P3+Q0)*T1/T)
3000 Q2=CEIL(MAX(Q0/2,Q1))
3100 W1=CEIL(Q2/(.000000004716*K5*(T3^4-255^4)))
4000 ! WEIGHTS & VOLUMES
4005 IF C1<=50 THEN S1(1)=9.32 @ S2(1)=19.28+INT(9.031*C1^1.2115+.5)/100
4010 IF C1>50 THEN S1(1)=11.98 @ S2(1)=24.79+INT(10.686*C1^1.0014+.5)/100
4040 S2(2)=INT(125*S2(1)+.5)/100
4041 S0(6)=457
4045 S0(5)=INT(10*S0(6)*SIN(180/N)+.5)/10
4050 U=CEIL(N3/28) @ U1=INT(N3/U*100+.5)/100
4055 S4(1)=.02268*C1
4060 S4(2)=1.32*N3/U*S4(1)+.075*I0
4065 S4(3)=.02*N3 @ S4(4)=24.95
4075 S4(5)=1.105*(U*S4(2)+S4(3)+S4(4))+.7*I0+.0096*Q2/N2
4080 S4(6)=INT(47*S4(5)+.5)/1000
4085 S3(1)=INT(PI*(S1(1)/2)^2*S2(1)*100+.5)/100
4086 S1(2)=S0(5)-2*S2(2)*TAN(180/N)
4087 S1(3)=FLOOR(S1(2)/4.464/S1(1))
4088 S1(4)=CEIL(U/S1(3)) @ S1(5)=FP(N3/U)*U
4089 IF S1(5)#0 THEN S1(5)=CEIL(S1(3)/FP(N3/U)/U)
4090 S1(6)=S1(4)-S1(5)
4091 IF CEIL(N3/27)>U THEN 4099
```

```
4092 IF S1(4)<CEIL(U/FLOOR(S1(2)/5.33/S1(1))) THEN 4099
4093 IF S1(3)>24 THEN S0(1)=5*S1(1) ELSE S0(1)=4.5*S1(1)
4094 IF S1(3)=21 THEN S0(1)=4*S1(1)
4095 S1(3)=FLOOR(N3/U)
4096 IF S1(3)>24 THEN S0(2)=5*S1(1) ELSE S0(2)=4.5*S1(1)
4097 IF S1(3)=21 THEN S0(2)=4*S1(1)
4098 S1(2)=INT(140.2*5.33*S1(1)+.5)/100 @ GOTO 4105
4099 IF S1(3)>25 THEN S0(1)=6*S1(1) ELSE S0(1)=5.5*S1(1)
4100 IF S1(3)=22 THEN S0(1)=5*S1(1)
4101 S1(3)=FLOOR(N3/U)
4102 IF S1(3)>25 THEN S0(2)=6*S1(1) ELSE S0(2)=5.5*S1(1)
4103 IF S1(3)=22 THEN S0(2)=5*S1(1)
4104 S1(2)=INT(140.2*4.464*S1(1)+.5)/100
4105 S1(6)=1.25*(S1(5)*S0(1)+S1(6)*S0(2))
4110 S4(7)=CEIL(N2*(S4(5)+S4(6))+.015*(Q(3)*N-N2)*S1(6)*S0(5)+.5)
4120 S3(2)=INT(S1(2)*S0(1)*S2(2)+.5)
4125 S3(3)=INT(S1(2)*S0(2)*S2(2)+.5)
4130 S1(4)=INT(20.3*N3/11+.5)/10
4135 S0(3)=12.7 @ S2(3)=6.4
4145 S3(4)=INT(S1(4)*S0(3)*S2(3)+.5)
4150 S1(5)=63.5 @ S0(4)=26.9 @ S2(4)=16.5 @ S3(5)=28184
4175 S2(5)=INT(10.75*MAX(S2(2),S0(4))+.5)/10
4180 S3(6)=INT(S1(6)*S0(5)*S2(5)+.5)
4190 S1(7)=S1(6)*Q(3)
4200 S3(7)=INT(S1(7)*N/4*S0(5)^2*COT(180/N)+.5)
4500 !  LIFE CYCLE COSTS
4501 F0(1)=INT((20*C1+1000)*N4^-.1047+.5)
4505 F0(2)=INT(.34*N4+.0014*F0(1)*N4+727+.5)/1000
4510 F0(3)=INT(.25*N4+.13*N4*S4(1)+1049+.5)/1000
4515 F0(4)=INT(.705*N2*U*S4(2)+607+.5)/1000
4520 F0(5)=INT(.172*N2*(S4(5)+S4(6))+1329+.5)/1000
4525 F0(6)=INT(.32*N4+.045*S4(7)+694+.5)/1000
4530 F0(7)=INT(.039*S4(7)+60+.5)/1000
4535 K6=CEIL(14.136*S1(7))/S4(7)
4540 IF K6<1 THEN K6=1
4545 IF L=5 THEN F0(8)=INT((5.1+8.14*K6)*S4(7)+.5)/1000 @ GOTO 4550
                                                                          4547 IF L#5 THEN F0(8)=INT(1.99*K6*S4(7)+.5)/1000
4550 F0(9)=INT(.011*S4(7)+.5)/1000
4555 F0=F0(2)+F0(3)+F0(4)+F0(5)+F0(6)+F0(7)+F0(8)+F0(9)
4560 F1(1)=INT(844*S4(7)^.203+.5)/1000
4565 F1(2)=INT(989*((1+S5(1))*(F0(2)+F0(3)+F0(4)+F0(5)+F0(6)))^1.064+.5)/1000
4570 F1(3)=INT(217*F1(2)^.789+.5)/1000
4575 F1(4)=INT(828*F1(2)^.397+.5)/1000
4580 F1(5)=INT(109*(F1(1)+F1(2)+F1(3)+F1(4))^1.025+.5)/1000
4585 F1(6)=INT(94*(F1(1)+F1(2)+F1(3)+F1(4)+F1(5))^.865+.5)/1000
4590 F1(7)=INT(131*(F1(1)+F1(2)+F1(3)+F1(4)+F1(5)+F1(6))^.865+.5)/1000
4595 F1=W(1)*F1(1)+W(2)*F1(2)+W(3)*F1(3)+W(4)*F1(4)+W(5)*F1(5)+W(6)*F1(6)+W(7)*F1(7)
4597 F1=INT(F1*1000+.5)/1000
4600 IF L=5 THEN F2(1),F2(2),F2(4)=0 @ F2(3)=.1*L1 @ GOTO 4635
4605 S5(2)=N8-1+N8*S5(1)
4610 S5(3)=L1*(.002*N2*U+.001*N8*CEIL(N2*U*S5(1))+.0015*(N8-1)*N2*U)
4615 F2(1)=INT(S5(2)*(F0(2)+F0(3))*1000+.5)/1000
4620 F2(2)=INT(82.5*S5(3)+.5)/1000
4625 F2(3)=INT(390*S5(3)+.5)/1000
4630 F2(4)=INT(3600*S5(3)+1.99*K6*S5(2)*S4(2)*N2*U+.5)/1000
4635 F2=F2(1)+F2(2)+F2(3)+F2(4)
4640 F3=F0+F1+F2
4645 IF L=5 THEN M=23.8 ELSE M=36.25+.545*L1
4646 F4=INT(M*P5^.803+.5)/1000
4650 F5(1)=INT(5200+.0825*Q2+1.5*W1+.5)/1000
4652 F5(2)=INT(200*N2^.848+.5)/1000
4655 F=F3+F4+F5(1)+F5(2)
```

```
4660 GOSUB 5000
4662 RESTORE @ NEXT L
4665 CLEAR @ BEEP 50,999 @ ASSIGN# 9 TO * @ DISP USING "7/,15X,5A" ; "DONE!" @ END
4900 ! C1 SUBROUTINE
4910 C1=50
4925 ! E0 SUBROUTINE
4930 E0=C1*K1*D9
4935 GOSUB 4950
4940 E0=C0/N2
4945 RETURN
4950 ! N2 SUBROUTINE
4955 N2=CEIL(C0/E0)
4960 IF N2<=4 THEN N2=4
4965 Q(3)=CEIL(N2/8)
4970 N=CEIL(N2/Q(3))
4975 RETURN
5000 ! DATA STORE SUBROUTINE
5002 IF G0=1 THEN X(1)=G9
5004 IF G0=2 THEN X(1)=G1
5006 IF G0=3 THEN X(1)=G2
5008 IF G0=4 THEN X(1)=P0
5010 IF G0>4 THEN X(1)=0
5012 X(2)=N0
5014 X(3)=T1
5016 X(4)=T
5018 X(5)=L1
5020 X(6)=N3
5022 X(7)=P5
5024 X(8)=V0
5026 X(9)=L0
5028 X(10)=L2
5030 X(11)=K1
5032 X(12)=K2
5034 X(13)=P3
5036 X(14)=V4
5038 X(15)=N4
5040 X(16)=N2
5042 X(17)=N3
5044 X(18)=U
5046 X(19)=U1
5048 X(20)=C1
5050 X(21)=D0
5052 X(22)=E0
5054 X(23)=I0
5056 X(24)=V1
5058 X(25)=R0
5060 X(26)=C4
5062 X(27)=I1
5064 X(28)=V3
5066 X(29)=N7
5068 X(30)=I3
5069 X(31)=V2
5070 X(32)=Q0
5072 X(33)=Q1
5074 X(34)=Q2
5076 X(35)=P5
5078 X(36)=W0
5080 X(37)=W1
5082 X(38)=K6
5084 X(39)=S4(1)
5086 X(40)=S4(2)
5088 X(41)=S4(3)
```

```
5090 X(42)=S4(4)
5092 X(43)=S4(5)
5094 X(44)=S4(6)
5096 X(45)=S4(7)
5098 X(46)=0
5100 X(47)=S1(1)
5102 X(48)=S2(1)
5104 X(49)=S1(2)
5106 X(50)=S0(1)
5108 X(51)=S2(2)
5110 X(52)=S1(2)
5112 X(53)=S0(2)
5114 X(54)=S2(2)
5116 X(55)=S1(4)
5118 X(56)=S0(3)
5120 X(57)=S2(3)
5122 X(58)=S1(5)
5124 X(59)=S0(4)
5126 X(60)=S2(4)
5128 X(61)=S1(6)
5130 X(62)=S0(5)
5132 X(63)=S2(5)
5134 X(64)=S1(7)
5136 X(65)=S0(6)
5138 X(66)=S0(5)
5140 X(67)=S3(1
5142 X(68)=S3(2)
5144 X(69)=S3(3)
5146 X(70)=S3(4)
5148 X(71)=S3(5)
5150 X(72)=S3(6)
5152 X(73)=S3(7)
5154 X(74)=F1
5156 X(75)=F0
5158 X(76)=F0(1)
5160 X(77)=F0(2)
5162 X(78)=F0(3)
5164 X(79)=F0(4)
5166 X(80)=F0(5)
5168 X(81)=F0(6)
5170 X(82)=F0(7)
5172 X(83)=F0(8)
5174 X(84)=F0(9)
5176 X(85)=F2
5178 X(86)=F2(1)
5180 X(87)=F2(2)
5182 X(88)=F2(3)
5184 X(89)=F2(4)
5186 X(90)=F3
5188 X(91)=F4
5190 X(92)=F5(1)
5192 X(93)=F5(2)
5194 X(94)=F
5196 PRINT# 9,G0 ; X()
5198 RETURN
6000 ! RECHARGE SEARCH SUBROUTINE (R1)
6010 C=R1
6020 C=C+.1
6030 GOSUB 9000
6040 IF Z9<D0 THEN 6020
6050 C=C-.01
6060 GOSUB 9000
```

```
6070 IF Z9>D0 THEN 6050
6080 C=C+.001
6090 GOSUB 9000
6100 IF Z9<D0 THEN 6080
6110 C=C-.0001
6120 GOSUB 9000
6130 IF Z9>D0 THEN 6110
6135 IF C>=1 THEN 6220
6140 C=C+.00001
6150 GOSUB 9000
6160 IF Z9<D0 THEN 6140
6220 R9=C
6230 RETURN
6500 ! RECHARGE SEARCH SUBROUTINE (I1/C1/K1)
6505 R0=(.49+D0)/D0
6506 C,K1,R9=R0*D0
6510 B=.054
6520 B=B+.1
6530 GOSUB 7000 @ GOSUB 9000
6540 IF Z9<D0 THEN 6520
6550 B=B-.01
6560 GOSUB 7000 @ GOSUB 9000
6570 IF Z9>D0 THEN 6550
6580 B=B+.001
6590 GOSUB 7000 @ GOSUB 9000
6600 IF Z9<D0 THEN 6580
6610 B=B-.0001
6620 GOSUB 7000 @ GOSUB 9000
6630 IF Z9>D0 THEN 6610
6640 B=B+.00001
6650 GOSUB 7000 @ GOSUB 9000
6660 IF Z9<D0 THEN 6640
6670 I1=B*C1*K1
6680 RETURN
7000 ! 2 DIMENSION SUBROUTINE
7001 B0,B1,B2,B3=0
7005 IF B>E THEN 7090
7010 B4=0
7020 B4=B4+1
7030 IF B>=T(B4) THEN 7020
7040 IF B4=1 THEN 7070
7050 B0=(T(B4)-B)/(T(B4)-T(B4-1))
7060 GOTO 7160
7070 B2=(T(B4)-B)/(T(B4+1)-T(B4))
7080 GOTO 7160
7090 B4=5
7100 B4=B4-1
7110 IF B<=T(B4) THEN 7100
7120 IF B4=4 THEN 7150
7130 B1=(B-T(B4))/(T(B4+1)-T(B4))
7140 RETURN
7150 B3=(B-T(B4))/(T(B4)-T(B4-1))
7160 RETURN
7500 ! 3rd DIMENSION SUBROUTINE
7501 A0,A1,A2,A3=0
7502 IF A>283 THEN 7545
7505 A4=0
7510 A4=A4+1
7515 IF A>=S(A4) THEN 7510
7520 IF A4=1 THEN 7535
7525 A0=(S(A4)-A)/(S(A4)-S(A4-1))
7530 RETURN
```

```
7535 A2=(S(A4)-A)/(S(A4+1)-S(A4))
7540 RETURN
7545 A4=6
7550 A4=A4-1
7555 IF A<=S(A4) THEN 7550
7560 IF A4=5 THEN 7575
7565 A1=(A-S(A4))/(S(A4+1)-S(A4))
7570 RETURN
7575 A3=(A-S(A4))/(S(A4)-S(A4-1))
7580 RETURN
8000 ! 3rd DIMENSION SUBROUTINE
8001 IF Q(2)=1 THEN 8500
8002 ON A4 GOTO 8004,8040,8058,8076,8094
8004 GOSUB 8410
8020 GOTO 8110
8040 GOSUB 8420
8056 GOTO 8110
8058 GOSUB 8430
8074 GOTO 8110
8076 GOSUB 8440
8092 GOTO 8110
8094 GOSUB 8450
8110 Z0=Z9
8111 IF A>283 THEN 8232
8112 IF A4=1 THEN 8190
8114 ON A4-1 GOTO 8118,8154,8172
8118 GOSUB 8410
8134 GOTO 8222
8154 GOSUB 8420
8170 GOTO 8222
8172 GOSUB 8430
8188 GOTO 8222
8190 GOSUB 8420
8204 Z2=Z9
8206 GOSUB 8430
8220 Z3=Z9 @ GOTO 8223
8222 Z1=Z9
8223 IF A0=0 THEN 8228
8224 Z=Z0+A0*(Z1-Z0)
8226 RETURN
8228 Z=Z0+A2*(Z0-Z2)*((Z0-Z2)/(Z2-Z3))
8230 RETURN
8232 IF A4=5 THEN 8272
8234 ON A4-2 GOTO 823,8254
8236 GOSUB 8440
8252 GOTO 8304
8254 GOSUB 8450
8270 GOTO 8304
8272 GOSUB 8440
8286 Z2=Z9
8288 GOSUB 8430
8302 Z3=Z9 @ GOTO 8305
8304 Z1=Z9
8305 IF A1=0 THEN 8310
8306 Z=Z0-A1*(Z0-Z1)
8308 RETURN
8310 Z=Z0-A3*(Z2-Z0)*((Z2-Z0)/(Z3-Z2))
8312 RETURN
8410 FOR I=1 TO 4
8411 FOR J=1 TO 14
8412 A5(I,J)=U1(I,J)
8413 B5(I,J)=U6(I,J)
```

```
8414 NEXT J
8415 NEXT I
8416 GOSUB 9000
8417 RETURN
8420 FOR I=1 TO 4
8421 FOR J=1 TO 14
8422 A5(I,J)=U2(I,J)
8423 B5(I,J)=U7(I,J)
8424 NEXT J
8425 NEXT I
8426 GOSUB 9000
8427 RETURN
8430 FOR I=1 TO 4
8431 FOR J=1 TO 14
8432 A5(I,J)=U3(I,J)
8433 B5(I,J)=U8(I,J)
8434 NEXT J
8435 NEXT I
8436 GOSUB 9000
8437 RETURN
8440 FOR I=1 TO 4
8441 FOR J=1 TO 14
8442 A5(I,J)=U4(I,J)
8443 B5(I,J)=U9(I,J)
8444 NEXT J
8445 NEXT I
8446 GOSUB 9000
8447 RETURN
8450 FOR I=1 TO 4
8451 FOR J=1 TO 14
8452 A5(I,J)=U5(I,J)
8453 B5(I,J)=U0(I,J)
8454 NEXT J
8455 NEXT I
8456 GOSUB 9000
8457 RETURN
8500 ON A4 GOTO 8502,8520,8538,8556,8574
8502 GOSUB 8911
8518 GOTO 8590
8520 GOSUB 8920
8536 GOTO 8590
8538 GOSUB 8930
8554 GOTO 8590
8556 GOSUB 8940
8572 GOTO 8590
8574 GOSUB 8950
8590 Z0=Z9
8591 IF A>283 THEN 8690
8592 IF A4=1 THEN 8648
8593 ON A4-1 GOTO 8594,8612,8630
8594 GOSUB 8911
8610 GOTO 8680
8612 GOSUB 8920
8628 GOTO 8680
8630 GOSUB 8930
8646 GOTO 8680
8648 GOSUB 8920
8662 Z2=Z9
8664 GOSUB 8930
8678 Z3=Z9 @ GOTO 8681
8680 Z1=Z9
8681 IF A0=0 THEN 8686
```

```
8682 Z=Z0+A0*(Z1-Z0)
8684 RETURN
8686 Z=Z0+A2*(Z0-Z2)*((Z0-Z2)/(Z2-Z3))
8688 RETURN
8690 IF A4=5 THEN 8730
8692 ON A4-2 GOTO 8694,8712
8694 GOSUB 8940
8710 GOTO 8762
8712 GOSUB 8950
8728 GOTO 8762
8730 GOSUB 8940
8744 Z2=Z9
8746 GOSUB 8930
8760 Z3=Z9 @ GOTO 8763
8762 Z1=Z9
8763 IF A1=0 THEN 8768
8764 Z=Z0-A1*(Z0-Z1)
8766 RETURN
8768 Z=Z0-A3*(Z2-Z0)*((Z2-Z0)/(Z3-Z2))
8770 RETURN
8911 FOR I=1 TO 4
8912 FOR J=1 TO 14
8913 A5(I,J)=N1(I,J)
8914 B5(I,J)=N6(I,J)
8915 NEXT J
8916 NEXT I
8917 GOSUB 9000
8919 RETURN
8920 FOR I=1 TO 4
8921 FOR J=1 TO 14
8922 A5(I,J)=N2(I,J)
8923 B5(I,J)=N7(I,J)
8924 NEXT J
8925 NEXT I
8926 GOSUB 9000
8927 RETURN
8930 FOR I=1 TO 4
8931 FOR J=1 TO 14
8932 A5(I,J)=N3(I,J)
8933 B5(I,J)=N8(I,J)
8934 NEXT J
8935 NEXT I
8936 GOSUB 9000
8937 RETURN
8940 FOR I=1 TO 4
8941 FOR J=1 TO 14
8942 A5(I,J)=N4(I,J)
8943 B5(I,J)=N9(I,J)
8944 NEXT J
8945 NEXT I
8946 GOSUB 9000
8947 RETURN
8950 FOR I=1 TO 4
8951 FOR J=1 TO 14
8952 A5(I,J)=N5(I,J)
8953 B5(I,J)=N0(I,J)
8954 NEXT J
8955 NEXT I
8956 GOSUB 9000
8957 RETURN
9000 ! INTERPOLATION SUBROUTINE
9003 X0(I),X1(I),X2(I),X3(I)=0
```

```
9005 IF C>A5(B4,7) THEN 9035
9010 G=0
9015 G=G+1
9020 IF C>=A5(B4,G) THEN 9015
9025 X0(2)=(A5(B4,G)-C)/(A5(B4,G)-A5(B4,G-1))
9030 GOTO 9055
9035 IF Q(1)=1 THEN 9010
9036 G=15
9040 G=G-1
9045 IF C<=A5(B4,G) THEN 9040
9050 X0(1)=(C-A5(B4,G))/(A5(B4,G+1)-A5(B4,G))
9055 IF B>L THEN 9315
9060 IF B4=1 THEN 9095
9065 IF C>A5(B4-1,7) THEN 914
9070 H=0
9075 H=H+1
9080 IF C>=A5(B4-1,H) THEN 9075
9085 X1(2)=(A5(B4-1,H)-C)/(A5(B4-1,H)-A5(B4-1,H-1))
9090 GOTO 9210
9095 IF C>A5(B4+1,7) THEN 9170
9100 H=0
9105 H=H+1
9110 IF C>=A5(B4+1,H) THEN 9105
9115 X2(2)=(A5(B4+1,H)-C)/(A5(B4+1,H)-A5(B4+1,H-1))
9120 J=0
9125 J=J+1
9130 IF C>=A5(B4+2,J) THEN 9125
9135 X3(2)=(A5(B4+2,J)-C)/(A5(B4+2,J)-A5(B4+2,J-1))
9140 GOTO 9210
9145 IF Q(1)=1 THEN 9070
9146 H=15
9150 H=H-1
9155 IF C<=A5(B4-1,H) THEN 9150
9160 X1(1)=(C-A5(B4-1,H))/(A5(B4-1,H+1)-A5(B4-1,H))
9165 GOTO 9210
9170 IF Q(1)=1 THEN 9100
9171 H=15
9175 H=H-1
9180 IF C<=A5(B4+1,H) THEN 9175
9185 X2(1)=(C-A5(B4+1,H))/(A5(B4+1,H+1)-A5(B4+1,H))
9190 J=15
9195 J=J-1
9200 IF C<=A5(B4+2,J) THEN 9195
9205 X3(1)=(C-A5(B4+2,J))/(A5(B4+2,J+1)-A5(B4+2,J))
9210 IF X0(1)=0 THEN 9225
9215 Y0=B5(B4,G)-X0(1)*(B5(B4,G)-B5(B4,G+1))
9220 GOTO 9230
9225 Y0=B5(B4,G)+X0(2)*(B5(B4,G-1)-B5(B4,G))
9230 IF B4=1 THEN 9265
9235 IF X1(1)=0 THEN 9250
9240 Y1=B5(B4-1,H)-X1(1)*(B5(B4-1,H)-B5(B4-1,H+1))
9245 GOTO 9255
9250 Y1=B5(B4-1,H)+X1(2)*(B5(B4-1,H-1)-B5(B4-1,H))
9255 IF Q(1)=1 THEN 9260
9256 Z9=Y0+B0*(Y1-Y0)
9257 RETURN
9260 Z9=T(B4)-(C4-Y0)/(Y1-Y0)*(T(B4)-T(B4-1))
9261 RETURN
9265 IF X2(1)=0 THEN 9280
9270 Y2=B5(B4+1,H)-X2(1)*(B5(B4+1,H)-B5(B4+1,H+1))
9275 GOTO 9285
9280 Y2=B5(B4+1,H)+X2(2)*(B5(B4+1,H-1)-B5(B4+1,H))
```

```
9285 IF X3(1)=0 THEN 9300
9290 Y3=B5(B4+2,J)-X3(1)*(B5(B4+2,J)-B5(B4+2,J+1))
9295 GOTO 9305
9300 Y3=B5(B4+2,J)+X3(2)*(B5(B4+2,J-1)-B5(B4+2,J))
9305 IF Q(1)=1 THEN 9310
9306 Z9=Y0+B2*(Y0-Y2)*((Y0-Y2)/(Y2-Y3))
9307 RETURN
9310 Z9=T(B4)-(Y0-C4)/(Y2-Y0)*(T(B4+1)-T(B4))*(T(B4+1)-T(B4))/(T(B4+2)-T(B4+1))
9311 RETURN
9315 IF B4=4 THEN 9350
9320 IF C>A5(B4+1,7) THEN 9400
9325 H=0
9330 H=H+1
9335 IF C>=A5(B4+1,H) THEN 9330
9340 X1(2)=(A5(B4+1,H)-C)/(A5(B4+1,H)-A5(B4+1,H-1))
9345 GOTO 9465
9350 IF C>A5(B4-1,7) THEN 9425
9355 H=0
9360 H=H+1
9365 IF C>=A5(B4-1,H) THEN 9360
9370 X2(2)=(A5(B4-1,H)-C)/(A5(B4-1,H)-A5(B4-1,H-1))
9375 J=0
9380 J=J+1
9385 IF C>=A5(B4-2,J) THEN 9380
9390 X3(2)=(A5(B4-2,J)-C)/(A5(B4-2,J)-A5(B4-2,J-1))
9395 GOTO 9465
9400 IF Q(1)=1 THEN 9325
9401 H=15
9405 H=H-1
9410 IF C<=A5(B4+1,H) THEN 9405
9415 X1(1)=(C-A5(B4+1,H))/(A5(B4+1,H+1)-A5(B4+1,H))
9420 GOTO 9465
9425 IF Q(1)=1 THEN 9355
9426 H=15
9430 H=H-1
9435 IF C<=A5(B4-1,H) THEN 9430
9440 X2(1)=(C-A5(B4-1,H))/(A5(B4-1,H+1)-A5(B4-1,H))
9445 J=15
9450 J=J-1
9455 IF C<=A5(B4-2,J) THEN 9450
9460 X3(1)=(C-A5(B4-2,J))/(A5(B4-2,J+1)-A5(B4-2,J))
9465 IF X0(1)=0 THEN 9480
9470 Y0=B5(B4,G)-X0(1)*(B5(B4,G)-B5(B4,G+1))
9475 GOTO 9485
9480 Y0=B5(B4,G)+X0(2)*(B5(B4,G-1)-B5(B4,G))
9485 IF B4=4 THEN 9520
9490 IF X1(1)=0 THEN 9505
9495 Y1=B5(B4+1,H)-X1(1)*(B5(B4+1,H)-B5(B4+1,H+1))
9500 GOTO 9510
9505 Y1=B5(B4+1,H)+X1(2)*(B5(B4+1,H-1)-B5(B4+1,H))
9510 IF Q(1)=1 THEN 515
9511 Z9=Y0-B1*(Y0-Y1)
9512 RETURN
9515 Z9=T(B4)+(Y0-C4)/(Y0-Y1)*(T(B4+1)-T(B4))
9516 RETURN
9520 IF X2(1)=0 THEN 9535
9525 Y2=B5(B4-1,H)-X2(1)*(B5(B4-1,H)-B5(B4-1,H+1))
9530 GOTO 9540
9535 Y2=B5(B4-1,H)+X2(2)*(B5(B4-1,H-1)-B5(B4-1,H))
9540 IF X3(1)=0 THEN 9555
9545 Y3=B5(B4-2,J)-X3(1)*(B5(B4-2,J)-B5(B4-2,J+1))
9550 GOTO 9560
```

```
9555 Y3=B5(B4-2,J)+X3(2)*(B5(B4-2,J-1)-B5(B4-2,J))
9560 IF Q(1)=1 THEN 9565
9561 Z9=Y0-B3*(Y2-Y0)*((Y2-Y0)/(Y3-Y2))
9562 RETURN
9565 Z9=T(B4)+(C4-Y0)/(Y0-Y2)*(T(B4)-T(B4-1))*(T(B4)-T(B4-1))/(T(B4-1)-T(B4-2))
9570 RETURN
```

```
10 ! "DATA5*"
15 OPTION BASE 1
20 DIM V6(4,14),D6(4,14)
30 ! CREATE "DATA5",2,768
40 ASSIGN# 1 TO "DATA5"
50 FOR I=1 TO 4
60 FOR J=1 TO 14
70 READ D6(I,J) ! LIFE YEARS
80 NEXT J
90 NEXT I
100 PRINT# 1,1 ; D6(,)
110 FOR I=1 TO 4
120 FOR J=1 TO 14
130 READ V6(I,J) ! DOD
140 NEXT J
150 NEXT I
160 PRINT# 1,2 ; V6(,)
170 ASSIGN# 1 TO *
180 DATA 0,.3,.7,1.2,1.7,2.3,3.3,4.7,6.65,12.65,13.8,14.6,15.4,16.05
190 DATA 0,.3,.65,1.05,1.6,2,3.1,4.2,6,12.6,13.6,14.4,15.05,15.65
200 DATA 0,.4,.9,1.45,2.1,2.8,4.2,5.85,8,11.8,12.9,14,14.6,15.2
210 DATA 0,.5,1,1.8,2.9,4.1,5.4,7.1,8.7,10.3,11.3,12.15,12.9,13.8
220 DATA 1.04,.985,.92,.86,.81,.76,.69,.6,.5,.23,.17,.12,.06,0
230 DATA .99,.935,.88,.83,.78,.75,.67,.6,.5,.2,.15,.1,.05,0
240 DATA .93,.86,.805,.75,.7,.65,.56,.47,.37,.2,.15,.09,.05,0
250 DATA .76,.705,.66,.6,.53,.46,.39,.31,.24,.17,.13,.09,.05,0
260 END
```

```
10 ! "DATA6*"
15 OPTION BASE 1
20 DIM V6(4,14),D6(4,14)
30 ! CREATE "DATA6",2,768
40 ASSIGN# 1 TO "DATA6"
50 FOR I=1 TO 4
60 FOR J=1 TO 14
70 READ D6(I,J) ! CHARGE
80 NEXT J
90 NEXT I
100 PRINT# 1,1 ; D6(,)
110 FOR I=1 TO 4
120 FOR J=1 TO 14
130 READ V6(I,J) ! DEPTH OF DIS-CHARGE
140 NEXT J
150 NEXT I
160 PRINT# 1,2 ; V6(,)
170 ASSIGN# 1 TO *
180 DATA 0,.6,.645,.725,.815,.905,.995,1.08,1.165,1.255,1.35,1.47,1.49,1.6
190 DATA 0,.6,.645,.73,.815,.88,.955,1.025,1.085,1.15,1.22,1.3,1.4,1.6
200 DATA 0,.6,.645,.73,.86,.935,1,1.055,1.11,1.15,1.2,1.275,1.35,1.6
220 DATA 0,.6,.645,.73,.86,1,1.06,1.1,1.1425,1.19,1.235,1.29,1.4,1.6
230 DATA 0,.56,.6,.65,.7,.735,.7575,.77,.7775,.785,.79,.795,.795,.7925
240 DATA 0,.56,.6,.675,.73,.765,.8,.825,.845,.86,.8725,.88,.8875,.89
250 DATA 0,.56,.6,.675,.785,.83,.865,.89,.91,.92,.93,.94,.945,.95
270 DATA 0,.56,.6,.675,.785,.89,.935,.96,.9825,1,1.0075,1.01,1.005,.995
280 END
```

```
10 ! "DATA7*"
15 OPTION BASE 1
20 DIM D6(4,14),V6(4,14)
40 ! CREATE "DATA7",10,768
50 ASSIGN# 1 TO "DATA7"
55 FOR N=1 TO 5
60 FOR I=1 TO 4
70 FOR J=1 TO 14
80 READ D6(I,J) ! DOD
100 NEXT J
110 NEXT I
120 PRINT# 1,N ; D6(,)
130 NEXT N
140 FOR K=1 TO 5
150 FOR L=1 TO 4
160 FOR M=1 TO 14
170 READ V6(L,M) ! DISCHARGE VOLTAGE
180 NEXT M
190 NEXT L
200 PRINT# 1,K+5 ; V6(,)
210 NEXT K
220 ASSIGN# 1 TO *
230 DATA 0,.025,.06,.105,.18,.325,.93,1,1.05,1.075,1.075,1.19,1.255,1.27
240 DATA 0,.025,.055,.1,.175,.305,.88,.95,.995,1.02,1.02,1.125,1.19,1.205
250 DATA 0,.025,.055,.1,.17,.3,.86,.925,.97,.995,.995,1.1,1.16,1.175
260 DATA 0,.02,.055,.095,.165,.295,.84,.905,.95,.975,.975,1.075,1.135,1.15
270 DATA 0,.025,.06,.105,.18,.32,.915,.985,1.03,1.06,1.06,1.17,1.235,1.25
280 DATA 0,.025,.055,.1,.17,.3,.865,.935,.975,1.005,1.005,1.11,1.17,1.185
290 DATA 0,.025,.055,.095,.165,.295,.85,.91,.955,.98,.98,1.085,1.145,1.16
300 DATA 0,.02,.05,.095,.165,.29,.83,.89,.935,.96,.96,1.06,1.115,1.135
310 DATA 0,.02,.055,.1,.175,.31,.885,.955,1,1.025,1.025,1.13,1.195,1.21
320 DATA 0,.025,.055,.095,.165,.29,.84,.905,.945,.975,.975,1.075,1.13,1.15
330 DATA 0,.02,.05,.095,.16,.285,.82,.885,.925,.95,.95,1.05,1.105,1.12
340 DATA 0,.02,.05,.09,.155,.28,.8,.865,.905,.93,.93,1.025,1.08,1.095
350 DATA 0,.02,.055,.095,.165,.29,.835,.895,.94,.965,.965,1.065,1.125,1.14
360 DATA 0,.025,.05,.09,.155,.275,.79,.85,.89,.915,.915,1.01,1.065,1.08
370 DATA 0,.025,.05,.09,.15,.27,.77,.83,.87,.895,.895,.985,1.04,1.055
380 DATA 0,.02,.05,.085,.15,.265,.755,.81,.85,.875,.875,.965,1.015,1.03
390 DATA 0,.02,.045,.08,.135,.235,.68,.735,.765,.79,.79,.87,.92,.93
400 DATA 0,.025,.04,.075,.125,.225,.645,.695,.725,.75,.75,.825,.87,.88
410 DATA 0,.02,.04,.07,.125,.22,.63,.68,.71,.73,.73,.805,.85,.86
420 DATA 0,.015,.04,.07,.12,.215,.615,.665,.695,.715,.715,.79,.83,.84
430 DATA 1.75,1.605,1.545,1.505,1.485,1.475,1.4,1.37,1.315,1.245,1.015,.94,.84,0
440 DATA 1.615,1.49,1.425,1.39,1.37,1.36,1.29,1.265,1.215,1.15,.94,.87,.78,0
450 DATA 1.56,1.43,1.375,1.345,1.325,1.315,1.245,1.22,1.175,1.11,.91,.84,.755,0
460 DATA 1.505,1.38,1.33,1.295,1.275,1.27,1.205,1.18,1.135,1.075,.88,.815,.73,0
470 DATA 1.71,1.565,1.505,1.465,1.445,1.435,1.36,1.33,1.275,1.205,.975,.9,.8,0
480 DATA 1.575,1.45,1.385,1.35,1.33,1.32,1.25,1.225,1.175,1.11,.9,.83,.74,0
490 DATA 1.52,1.39,1.335,1.305,1.285,1.275,1.205,1.18,1.135,1.07,.87,.8,.715,0
500 DATA 1.465,1.34,1.29,1.255,1.235,1.23,1.165,1.14,1.095,1.035,.84,.775,.69,0
510 DATA 1.69,1.545,1.485,1.445,1.425,1.415,1.34,1.31,1.255,1.185,.955,.88,.78,0
520 DATA 1.555,1.42,1.365,1.33,1.31,1.3,1.23,1.205,1.155,1.09,.88,.81,.72,0
530 DATA 1.5,1.375,1.315,1.285,1.265,1.255,1.185,1.16,1.115,1.05,.85,.78,.695,0
540 DATA 1.445,1.32,1.27,1.235,1.215,1.21,1.145,1.12,1.075,1.015,.82,.755,.67,0
550 DATA 1.67,1.525,1.465,1.425,1.405,1.395,1.32,1.29,1.235,1.165,.935,.86,.76,0
560 DATA 1.535,1:41,1.345,1.31,1.29,1.28,1.21,1.185,1.135,1.07,.86,.79,.7,0
570 DATA 1.48,1.35,1.295,1.265,1.245,1.235,1.165,1.14,1.095,1.03,.83,.76,.675,0
580 DATA 1.425,1.3,1.25,1.215,1.195,1.19,1.125,1.1,1.055,.995,.8,.735,.65,0
590 DAA 1.63,1.485,1.425,1.385,1.365,1.355,1.28,1.25,1.195,1.125,.895,.82,.72,0
600 DATA 1.495,1.36,1.31,1.27,1.25,1.24,1.17,1.145,1.095,1.03,.82,.75,.66,0
610 DATA 1.44,1.31,1.255,1.225,1.205,1.195,1.125,1.1,1.055,.99,.79,.72,.635,0
620 DATA 1.385,1.26,1.21,1.175,1.155,1.15,1.085,1.06,1.015,.955,.76,.695,.61,0
630 END
```

```
10 ! "DATAS*"
15 OPTION BASE 1
20 DIM D6(4,14),V6(4,14)
30 ! CREATE "DATA8",10,768
40 ASSIGN# 1 TO "DATA8"
50 FOR H=1 TO 5
60 FOR I=1 TO 4
70 FOR J=1 TO 14
80 READ D6(I,J) ! CHARGE THRU-PUT
90 NEXT J
100 NEXT I
110 PRINT# 1,H ; D6(,)
120 NEXT H
130 FOR K=1 TO 5
140 FOR L=1 TO 4
150 FOR M=1 TO 14
160 READ V6(L,M) ! CHARGE VOLTAGE
170 NEXT M
180 NEXT L
190 PRINT# 1,K+5 ; V6(,)
200 NEXT K
210 ASSIGN# 1 TO *
221 DATA .1,.2,.3,.5,.6,.7,.8,.955,1.07,1.2,1.28,1.33,1.43,1.5
231 DATA .1,.2,.3,.5,.6,.7,.8,.955,1.07,1.2,1.28,1.33,1.43,1.5
241 DATA .1,.2,.3,.5,.6,.7,.8,.955,1.07,1.2,1.28,1.33,1.43,1.5
251 DATA .1,.2,.3,.5,.6,.7,.8,.955,1.07,1.2,1.28,1.33,1.43,1.5
261 DATA .1,.2,.3,.5,.6,.7,.8,.955,1.07,1.2,1.28,1.33,1.43,1.5
271 DATA .1,.2,.3,.5,.6,.7,.8,.955,1.07,1.2,1.28,1.33,1.43,1.5
281 DATA .1,.2,.3,.5,.6,.7,.8,.955,1.07,1.2,1.28,1.33,1.43,1.5
291 DATA .1,.2,.3,.5,.6,.7,.8,.955,1.07,1.2,1.28,1.33,1.43,1.5
301 DATA .1,.2,.3,.5,.6,.7,.8,.955,1.07,1.2,1.28,1.33,1.43,1.5
311 DATA .1,.2,.3,.5,.6,.7,.8,.955,1.07,1.2,1.28,1.33,1.43,1.5
321 DATA .1,.2,.3,.5,.6,.7,.8,.955,1.07,1.2,1.28,1.33,1.43,1.5
331 DATA .1,.2,.3,.5,.6,.7,.8,.955,1.07,1.2,1.28,1.33,1.43,1.5
341 DATA .1,.2,.3,.5,.6,.7,.8,.955,1.07,1.2,1.28,1.33,1.43,1.5
351 DATA .1,.2,.3,.5,.6,.7,.8,.955,1.07,1.2,1.28,1.33,1.43,1.5
361 DATA .1,.2,.3,.5,.6,.7,.8,.955,1.07,1.2,1.28,1.33,1.43,1.5
371 DATA .1,.2,.3,.5,.6,.7,.8,.955,1.07,1.2,1.28,1.33,1.43,1.5
381 DATA .1,.2,.3,.5,.6,.7,.8,.955,1.07,1.2,1.28,1.33,1.43,1.5
391 DATA .1,.2,.3,.5,.6,.7,.8,.955,1.07,1.2,1.28,1.33,1.43,1.5
401 DATA .1,.2,.3,.5,.6,.7,.8,.955,1.07,1.2,1.28,1.33,1.43,1.5
411 DATA .1,.2,.3,.5,.6,.7,.8,.955,1.07,1.2,1.28,1.33,1.43,1.5
421 DATA 1.4775,1.485,1.4925,1.5075,1.515,1.5225,1.5275,1.535,1.5375,1.54,1.54,1.54,1.54,1.54
431 DATA 1.4875,1.495,1.5025,1.5175,1.525,1.5325,1.54,1.55,1.555,1.5575,1.5575,1.5575,1.5575,1.557
441 DATA 1.495,1.5025,1.51,1.5275,1.535,1.5425,1.55,1.5625,1.57,1.575,1.5775,1.5775,1.5775,1.575
451 DATA 1.505,1.515,1.5225,1.54,1.5475,1.555,1.5625,1.575,1.585,1.5975,1.6025,1.605,1.6025,1.59
461 DATA 1.4375,1.445,1.4525,1.4625,1.475,1.4825,1.4875,1.495,1.4975,1.5,1.5,1.5,1.5,1.5
471 DATA 1.4475,1.455,1.4625,1.4775,1.485,1.4925,1.5,1.51,1.515,1.5175,1.5175,1.5175,1.5175,1.5175
481 DATA 1.455,1.4625,1.47,1.4875,1.495,1.5025,1.51,1.5225,1.53,1.535,1.5375,1.5375,1.5375,1.535
491 DATA 1.465,1.475,1.4825,1.5,1.5075,1.515,1.5225,1.535,1.545,1.5575,1.5625,1.565,1.5625,1.5575
501 DATA 1.4175,1.425,1.5325,1.4475,1.455,1.4625,1.4675,1.475,1.4775,1.48,1.48,1.48,1.48,1.48
511 DATA 1.4275,1.435,1.4425,1.4575,1.465,1.4725,1.48,1.49,1.495,1.4975,1.4975,1.4975,1.4975,1.497
521 DATA 1.435,1.4425,1.45,1.4675,1.475,1.4825,1.49,1.5025,1.51,1.515,1.5175,1.5175,1.5175,1.515
531 DATA 1.445,1.455,1.4625,1.48,1.4875,1.495,1.5025,1.515,1.525,1.5375,1.5425,1.545,1.5425,1.5375
541 DATA 1.3475,1.405,1.4125,1.4275,1.435,1.4425,1.4475,1.455,1.4575,1.46,1.46,1.46,1.46,1.46
551 DATA 1.4075,1.415,1.4225,1.4375,1.445,1.4525,1.46,1.47,1.475,1.4775,1.4775,1.4775,1.4775,1.457
561 DATA 1.415,1.4225,1.43,1.4475,1.455,1.4625,147,1.4825,1.49,1.495,1.4975,1.4975,1.4975,1.495
571 DATA 1.425,1.435,1.4425,1.46,1.4675,1.475,1.4825,1.495,1.505,1.5175,1.5225,1.525,1.5225,1.5175
581 DATA 1.3575,1.365,1.3725,1.3875,1.395,1.4025,1.4075,1.415,1.4175,1.42,1.42,1.42,1.42,1.42
591 DATA 1.3675,1.375,1.3825,1.3975,1.405,1.4125,1.42,1.43,1.435,1.4375,1.4375,1.4375,1.4375,1.437
601 DATA 1.375,1.3825,1.39,1.4075,1.415,1.4225,1.43,1.4425,1.45,1.455,1.4575,1.4575,1.4575,1.455
611 DATA 1.365,1.395,1.4025,1.42,1.4275,1.435,1.4425,1.455,1.465,1.4775,1.4825,1.485,1.4825,1.4775
621 END
```

```
1 ! "F202","F",2
2 OPTION BASE 1
3 INTEGER N,N(3),N0(3),N5,N5(2)
4 SHORT C1,C2,D0,D1,D(2),D7(1),D8,E0,E1,E1(1),E2,E2(2),E7,E8,E8(2)
5 SHORT H2,H5,H6(2),H7,I0,I1,I2,I7,I8,J1(2),J2(2),K0(2),K1(2),K2(2),K5(7),K6,K7,K8
6 SHORT L(3),L0,L1,L2,L3,L6,M0,M1,M1(3),M2,M2(3),M3,M3(3),M4,M4(3),M7(2)
7 SHORT P1,P2,P(2),P6(3),P7(1),Q1(2),Q2(2),Q7,Q7(2),R1(1),R2(1)
8 SHORT S1(3),S2(3),S3(4),S4(4),S5(7),S6(2),S7(4),T0,T0(2),T1,T1(1),T2,T2(1),T3,T4,T6(3)
9 SHORT V1,V2,V3(2),V4(2),V5,V5(1),V6,V6(3),V7
10 SHORT W0(2,3),W1,W2,W3,W4,W5,W5(2),W6,W6(3,3),W7,W8,W9
11 SHORT A0(5),H(18),H0(8),O(18),U(18),U0(8)
12 DIM B(18),F0(12),F1(7),F2(4),X(128)
19 FOR I=1 TO 18
20 READ H(I)
21 DATA 0,26.9,38.3,43.056,86.111,129.17,145.1,172.22,215.28
22 DATA 258.33,301.39,344.45,387.5,430.56,473.61,516.67,559.72,602.78
23 NEXT I
24 FOR I=1 TO 18
25 READ O(I)
26 DATA .9859,.9699,.9632,.9588,.9341,.9129,.9064,.8953,.8782
27 DATA .8638,.8494,.8368,.8241,.8126,.8012,.7909,.7806,.7712
28 NEXT I
29 FOR I=1 TO 18
30 READ U(I)
31 DATA .084,.444,.528,.588,.94,1.212,1.296,1.436,1.564
32 DATA 1.668,1.716,1.788,1.848,1.94,2.012,2.14,2.224,2.352
33 NEXT I
34 FOR I=1 TO 8
35 READ H0(I)
36 DATA 0,67.12,139.46,216.35,297.73,383.67,474.26,569.54
38 NEXT I
39 FOR I=1 TO 8
40 READ U0(I)
41 DATA 0,.01537,.04372,.08039,.1276,.1832,.2496,.3263
43 NEXT I
44 READ A0(1),A0(2),A0(3),A0(4),A0(5)
45 DATA 1704.6,11358,45220,128457,303903
48 BEEP 100,500 @ CLEAR @ DISP USING "7/,10X,11A" ; "CHANGE TAPE" @ PAUSE
50 G9=9 @ CLEAR @ DISP USING "4/,X,30A,2/" ; "DON'T BOTHER ME, I'M THINKING!"
51 FOR L=1 TO 5
52 DISP USING "10X,4A,D" ; "L =",L ! KW Indicator
55 D(1)=.932 @ D(2)=.833 @ D7(1)=.9 @ D8=.935
56 E0=128.8 @ E1(1)=1.4 @ E2(1)=3.5 @ E8(2)=120
57 IF L=5 THEN H0=35786 ELSE H0=444
58 H6=.8 @ H6(1)=.1 @ H6(2)=.2
59 J1(2),J2(1)=2.5
60 IF L=5 THEN K0(1)=.24 @ K0(2)=.7854 ELSE K0(1)=.949 @ K0(2)=.6366
61 K3,K4,K6,K7=.1 @ K9=1
62 IF L=5 THEN L0=5 ELSE L0=30
63 IF L=5 THEN N(1),N(2),N(3),N0(3)=1 ELSE N(1),N(2),N(3),N0(3)=4
64 IF L=4 THEN P(1)=250000 ELSE P(1)=25000*CEIL((L/1.5)^2)
65 IF L=5 THEN P(1)=25000
66 P(2)=P(1)/10 @ P7(1)=P(1)/20
67 P1(1),P2(1)=1.1243 @ P6(1)=28.12 @ P6(2)=14.06 @ P6(3)=1.3357
68 R1(1),R2(1)=.00007518
69 S1(1),S2(1)=30.48 @ S1(2),S2(2)=7.62 @ S1(3),S2(3)=.9313
70 T0(1),T0(2)=.025 @ T1(1),T2(1),T5(1)=355 @ T6=50
80 RESTORE 84
81 FOR I=1 TO L
82 READ K5(1),K5(2),K5(3),K5(4),K5(5),K5(6),K5(7)
83 NEXT I
84 DATA .8,.45,.2,.5,.5,.5,.5
```

```
85 DATA .65,.45,.2,.45,.45,.45,.45
86 DATA .5,.4,.2,.4,.4,.4,.4
87 DATA .45,.3,.2,.35,.35,.35,.35
88 DATA .8,.45,.2,.5,.5,.5,.5
90 IF L=1 THEN CREATE "H202-1",G9,1024 ELSE 92
91 ASSIGN# 9 TO "H202-1" @ GOTO 100
92 IF L=2 THEN CREATE "H202-2",G9,1024 ELSE 94
93 ASSIGN# 9 TO "H202-2" @ GOTO 100
94 IF L=3 THEN CREATE "H202-3",G9,1024 ELSE 96
95 ASSIGN# 9 TO "H202-3" @ GOTO 100
96 IF L=4 THEN CREATE "H202-4",G9,1024 ELSE98
97 ASSIGN# 9 TO "H202-4" @ GOTO 100
98 IF L=5 THEN CREATE "H202-5",G9,1024 ELSE 100
99 ASSIGN# 9 TO "H202-5"
100 IF L<=4 THEN G1=1 ELSE G1=2 ! G1=1 FOR LEO,2 FOR GEO
101 G2=3 ! G2=1 FOR NICd,2 FOR NIH2,3 FOR H202
110 T0=.0000027645*(6375+H0)^(3/2)
120 N0=8766*K0(1)/T0*L0
130 DEG @ T1=T0/180*(90-ACS(6375/(6375+H0)))+T0(1)
140 T2=T0-T1-T0(2)
150 T3=K0(2)*T1
160 T4=T0-K0(2)*(T0-T2)
170 P0=INT(P(1)/D(1)+P(2)/D(2)+P7(1)/D7(1)+.5)
180 I0=P0/E0
190 L(1)=INT(T3*N0/N(1)+.5)
200 O1=E1(1)/2
201 GOSUB 6000
205 B0=L(1)
206 GOSUB 6025
207 J1(1)=H
210 C1=S1(1)*S1(2)
215 I1=J1(1)*C1/1000
220 N1(1)=CEIL(I0/I1)
230 N3(1)=1
240 N5=N1(1)/N3(1)
250 I1=I0/N1(1)
260 J1(1)=I1/C1*1000
270 H0=J1(1)
271 GOSUB 6050
272 L1=U
280 N0(1)=CEIL(T3*N0/L1)
290 U9=INT(T3*N0/N0(1)+.5)
300 IF L(1)#U9 THEN L(1)=U9 @ GOTO 205
310 I7=I1*N1(1)
320 B0=L(1)
321 GOSUB 6100
322 E1=U*2
330 P1=E1*I1
340 N1(2)=CEIL(E0/E1)
350 E7=E1*N1(2)
360 P7=INT(E7*I7+.5)
370 N3(2)=CEIL(N1(2)/60)
380 N1(3)=N1(2)/N3(2)
390 N3(3)=N3(1)*N3(2)
400 N1=N1(1)*N1(2)
410 N3=N3(3)*N5
420 H0=J1(1)
421 GOSUB 6150
422 K1(1)=U*2
430 Q1(1)=K1(1)*C1
440 H0=J1(2)
441 GOSUB 6150
```

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442 K1(2)=U*2
450 Q1(2)=K1(2)*C1
460 W0(1,1)=K1(1)*I1*T1
470 W0(1,2)=K1(1)*J1(2)*C1*T2/1000
480 W0(1,3)=W0(1,1)+W0(1,2)
490 W5(2)=W0(1,3)*N1
500 W6(1,1)=W5(2)/N6
510 C2=S2(1)*S2(2)
511 W0(2,1)=K2(1)*J2(1)*C2*T1/1000
520 L(2)=INT(T4*N0/N(2)+.5)
530 N2=1.2767-.00016022*T2(1)
531 O1=2*N2-E2(1)/2
532 GOSUB 6000
535 B0=L(2)
536 GOSUB 6025
537 J2(2)=N
540 I2=J2(2)*C2/1000
550 W0(2,2)=K2(1)*I2*T2
560 W0(2,3)=W0(2,1)+W0(2,2)
570 N2=CEIL(W5(2)/W0(2,3))
580 N2(2)=FLOOR(L8(2)/E2(1))
590 N2(1)=CEIL(N2/N2(2))
600 N2=N2(1)*N2(2)
610 W0(2,3)=W5(2)/N2
620 W0(2,2)=W0(2,3)-W0(2,1)
630 J2(2)=W0(2,2)/K2(1)/C2/T2*1000
640 N0=J2(2)
641 GOSUB 6100
642 E2=(2*N2-O)*2
650 U9=FLOOR(E8(2)/E2)
660 IF N2(2)#U9 THEN N2(2)=U9 @ GOTO 590
670 N0=J2(2)
671 GOSUB 6050
672 L2=U
680 N0(2)=CEIL(T4*N0/L2)
690 U9=INT(T4*N0/N0(2)+.5)
700 IF L(2)#U9 THEN L(2)=U9 @ GOTO 535
720 I2=J2(2)*C2/1000
730 P2=L2*I2
740 N4(2)=CEIL(N2(2)/60)
760 N2(3)=N2(2)/N4(2)
770 N4(1)=N2(1)/N5
780 N4(3)=N4(1)*N4(2)
790 N4=N4(3)*N5
800 E8=E2*N2(2)
810 I8=I2*N2(1)
820 P8=INT(E8*I8+.5)
830 D0=P7*T1/P8/T2
840 E8(1)=E8/D8
850 P8(1)=INT(E8(1)*I8+.5)
860 N0=J2(1)
861 GOSUB 6150
862 K2(1)=U*2
870 Q2(1)=K2(1)*C2
880 N0=J2(2)
881 GOSUB 6150
882 K2(2)=U*2
890 Q2(2)=K2(2)*C2
900 Q7(1)=INT(Q1(1)*N1+Q2(1)*N2+.5)
910 Q7(2)=INT(Q1(2)*N1+Q2(2)*N2+.5)
920 Q7=CEIL(MAX(Q7(1)/2,Q7(2)))
930 V1=INT((S1(1)+5.08)*(S1(2)+5.08)*S1(3)*100+.5)/100
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940 V2=INT((S2(1)+5.08)*(S2(2)+5.08)*S2(3)*100+.5)/100
950 S3(4)=INT((S1(3)*CEIL(N1(3))+9.57)*100+.5)/100
960 S3(3)=INT((S1(3)*FLOOR(N1(3))+9.57)*100+.5)/100
970 S3(2)=S1(2)+10.16
980 S3(1)=S1(1)+6.35
90 V3(2)=S3(1)*S3(2)*S3(4)
1000 V3(1)=S3(1)*S3(2)*S3(3)
1010 S4(4)=INT((S2(3)*CEIL(N2(3))+9.57)*100+.5)/100
1020 S4(3)=INT((S2(3)*FLOOR(N2(3))+9.57)*100+.5)/100
1030 S4(2)=S2(2)+10.16
1040 S4(1)=S2(1)+6.35
1050 V4(2)=S4(1)*S4(2)*S4(4)
1060 V4(1)=S4(1)*S4(2)*S4(3)
1070 S7(2)=457
1090 N=5
1100 S5(2),S7(3)=S7(2)*SIN(180/N)
1110 S5(3)=INT((MAX(S3(4),S4(4))+15.24)*100+.5)/100
1120 S5(4)=S5(2)-2*S5(3)*TAN(180/N)
1130 N7(1)=FLOOR(S5(4)/(MAX(S3(2),S4(2))+3.4925))
1140 N7(2)=CEIL((N3+N4)/N/N7(1))
1150 N5(1)=CEIL(N2(1)*12/35)
1151 S5(5)=63.5 @ S5(6)=26.9 @ S5(7)=16.5
1152 V5(1)=S5(5)*S5(6)*S5(7)
1160 U0=CEIL((N3+N4)/N/N7(1))
1161 U1=FLOOR(N3/N/N7(1))
1162 U2=FLOOR(N4/N/N7(1))
1163 S5(1),S7(1)=U1*(S3(1)+5.08)+U2*(S4(4)+5.08)+(U0-U1-U2)*(MAX(S3(1),S4(1))+5.08)+33.02
1170 S7(4)=S7(3)/2*COT(180/N)
1180 V5=(S5(2)*S7(4)-S5(4)*(S7(4)-S5(3)))*S5(1)/2
1190 S6(1)=1.5*(S7(4)-S5(3))
1200 S6(2)=.8*S7(1)
1210 V6=PI*(S6(1)/2)^2*S6(2)
1220 V7=S7(1)*N/4*S7(3)^2*COT(180/N)
1230 W1=INT(11.9*V1+.5)/10000
1240 W2=INT(11.9*V2+.5)/10000
1250 W3=INT(122.6*N1(3)*W1+.5)/100
1260 W4=INT(122.6*N2(3)*W2+.5)/100
1270 W5(1)=24.95
1280 W5=(1.025*(W3*N3+W4*N4+W5(1)*N5(1))+.25*(11*N3+12*N4)+.0096*Q7)/N
1290 W6(1,2)=7.9365*W6(1,1)
1300 W6(1,3)=8.9365*W6(1,1)
1310 V6(1)=84790*W6(1,1)/2.016*T6/P6(1)
1320 V6(2)=84790*W6(1,2)/16*T6/P6(2)
1330 V6(3)=1000*W6(1,3)
1340 U9=(V6(1)+V6(2))/(.9*V6-V6(3))
1341 IF U9<1 THEN S6(1)=S6(1)*U9^(1/3) @ S6(2)=S6(2)*U9^(1/3) @ V6=V6*U9 @ GOTO 1350
1342 IF U9>1 THEN P6(1)=P6(1)*U9 @ P6(2)=P6(2)*U9 @ V6(1)=V6(1)/U9 @ V6(2)=V6(2)/U9
1350 A0=V6(1) @ A1=P6(1)
1351 GOSUB 6200
1352 W6(2,1)=A
1360 A0=V6(2) @ A1=P6(2)
1361 GOSUB 6200
1362 W6(2,2)=A
1370 A0=V6(3) @ A1=P6(3)
1371 GOSUB 6200
1372 W6(2,3)=A/2
1380 W6(3,1)=W6(1,1)+W6(2,1)
1390 W6(3,2)=W6(1,2)+W6(2,2)
1400 W6(3,3)=W6(1,3)+W6(2,3)
1410 W6=INT(135*(W6(2,1)+W6(2,2)+W6(2,3)+W6(1,3))+.5)/100
1420 W7=INT(W5*N+W6+.5)
1430 W8=CEIL(.0205*P8(1))
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1440 W9(1)=CEIL(Q7/.000000004716/K9/(T5(1)^4-255^4))
1445 IF L=5 THEN N5(2)=CEIL(N1(1)*11/35) ELSE N5(2)=N5
1446 W9(2)=N5(2)*W5(1)
1450 L(3),L3=T0*N0/N(3)
2000 ! LIFE CYCLE COST
2010 F0(1)=INT(9.237*(C1/232.26)^.8*N1^-.152*1000+.5)/1000
2020 F0(2)=INT(9.237*(C2/232.26)^.8*N2^-.152*1000+.5)/1000
2030 F0(3)=INT(.25*N1+.13*N1*W1+1.1*N1*F0(1)+525.5)/1000
2040 F0(4)=INT(.25*N2+.13*N2*W2+1.1*N2*F0(2)+525.5)/1000
2050 F0(5)=INT(.705*(N3*W3+N4*W4)+200*N5(1)^.848+607.5)/1000
2060 F0(6)=INT(.0175*P7*(P6(1)/28.12)^.6*(L3/43830)^.9+.5)/1000
2070 F0(7)=INT(.172*W7+1329.5)/1000
2080 F0(8)=INT(.32*(N1+N2)+.15*W6+.045*W7+694.5)/1000
2090 F0(9)=INT(.039*W7+60.5)/1000
2095 K8=CEIL(14.136*S7(1))/W7
2096 IF K8<1 THEN K8=1
2100 F0(10)=INT(1.99*W7*K8+.5)/1000
2110 F0(11)=INT(.011*W7+.5)/1000
2120 F0(12)=INT((5.1+8.14*K8)*W7+.5)/1000
2130 F0=F0(3)+F0(4)+F0(5)+F0(6)+F0(7)+F0(8+F0(9)
2131 IF L=5 THEN F0=F0+F0(12) ELSE F0=F0+F0(10)+F0(11)
2140 F1(1)=INT(844*K5(1)*W7^.203+.5)/1000
2150 F1(2)=INT(989*K5(2)*(1+K7)*(F0(3)+F0(4)+F0(5)+F0(6)+F0(7)+F0(8))^1.064+.5)/1000
2160 F1(3)=INT(217*K5(3)*F1(2)^.789+.5)/1000
2170 F1(4)=INT(828*K5(4)*F1(2)^.397+.5)/1000
2175 F1=F1(1)+F1(2)+F1(3)+F1(4)
2180 F1(5)=INT(109*K5(5)*F1^1.025+.5)/1000
2185 F1=F1+F1(5)
2190 F1(6)=INT(94*K5(6)*F1^.865+.5)/1000
2195 F1=F1+F1(6)
2200 F1(7)=INT(131*K5(7)*F1^.865+.5)/1000
2210 F1=F1+F1(7)
2215 IF L=5 THEN F2(1),F2(2),F2(4)=0 @ F2(3)=.1*L0 @ GOTO 2260
2220 F2(1)=F0(3)*(N0(1)-1)+F0(4)*(N0(2)-1)+F0(6)*(N0(3)-1)*N6(2)
2221 F2(1)=F2(1)+K3*F0(3)*N0(1)+K4*F0(4)*N0(2)+K6*F0(6)*N0(3)*N6(1)
2222 F2(1)=INT(F2(1)*1000+.5)/1000
2230 N7=.002*(N3+N4)+.03+.001*N3*K3+.001*N4*K4+.002*K6
2231 N7=N7+.0015*N3*(N0(1)-1)+.0015*N4*(N0(2)-1)+.02*(N0(3)-1)
2232 F2(2)=INT(62.5*N7+.5)/1000
2240 F2(3)=INT(390*N7+.5)/1000
2250 F2(4)=W3*N3*N0(1)*K3+W4*N4*N0(2)*K4+W6*N0(3)*K6*N6(1)
2251 F2(4)=1.99*(F2(4)+W3*N3*(N0(1)-1)+W4*N4*(N0(2)-1)+W6*(N0(3)-1)*N6(2))
2252 F2(4)=INT(F2(4)+3600*N7+.5)/1000
2260 F2=F2(1)+F2(2)+F2(3)+F2(4)
2270 F7=F0+F1+F2
2280 IF L=5 THEN H=23.8 ELSE H=36.25+.545*L0
2281 F8=INT(H*P8(1)^.803+.5)/1000
2290 F9(1)=INT(5200+.0825*Q7+1.5*W9(1)+.5)/1000
2300 F9(2)=INT(200*N5(2)^.848+.5)/1000
2310 F=F7+F8+F9(1)+F9(2)
2320 GOSUB 3000
2330 RESTORE @ NEXT L
2340 CLEAR @ BEEP 50,999 @ ASSIGN# 9 TO * @ DISP USING "7/,15X,5A" ; "DONE!"
2350 END
3000 ! DATA STORE SUBROUTINE
3001 IF G0=1 THEN X(1)=G9
3002 IF G0=2 THEN X(1)=G1
3003 IF G0=3 THEN X(1)=G2
3004 IF G0=4 THEN X(1)=F(1)
3005 IF G0>4 THEN X(1)=0
3010 X(2)=N0
3015 X(3)=T1
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3020 X(4)=T2
3025 X(5)=L0
3030 X(6)=N0(1)
3035 X(7)=N0(2)
3040 X(8)=N0(3)
3045 X(9)=P0
3050 X(10)=E0
3055 X(11)=L(1)
3060 X(12)=L(2)
3065 X(13)=L(3)
3070 X(14)=P7
3075 X(15)=E7
3080 X(16)=L1
3085 X(17)=L2
3090 X(18)=L3
3095 X(19)=N
3100 X(20)=N5
3105 X(21)=N1
3110 X(22)=N1(1)
3115 X(23)=N1(2)
3120 X(24)=N3
3125 X(25)=N1(3)
3130 X(26)=P1
3135 X(27)=E1
3140 X(28)=C1
3145 X(29)=J1(1)
3150 X(30)=J1(2)
3155 X(31)=N2
3160 X(32)=N2(1)
3165 X(33)=N2(2)
3170 X(34)=N4
3175 X(35)=N2(3)
3180 X(36)=P2
3185 X(37)=E2
3190 X(38)=C2
3195 X(39)=J2(1)
3200 X(40)=J2(2)
3205 X(41)=P1(1)
3210 X(42)=T1(1)
3215 X(43)=P2(1)
3220 X(44)=T2(1)
3225 X(45)=Q7(1)
3230 X(46)=Q7(2)
3235 X(47)=Q7
3240 X(48)=D0
3245 X(49)=N6
3250 X(50)=T6
3255 X(51)=P6(1)
3260 X(52)=V6(1)
3265 X(53)=W6(1,1)
3270 X(54)=W6(2,1)
3275 X(55)=P6(2)
3280 X(56)=V6(2)
3285 X(57)=W6(1,2)
3290 X(58)=W6(2,2)
3295 X(59)=P6(3)
3300 X(60)=V6(3)
3305 X(61)=W6(1,3)
3310 X(62)=W6(2,3)
3315 X(63)=P8(1)
3320 X(64)=E8(1)
3325 X(65)=W8
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3330 X(66)=W9(1)
3335 X(67)=W9(2)
3340 X(68)=W1
3345 X(69)=W2
3350 X(70)=W3
3355 X(71)=W4
3360 X(72)=W5()
3365 X(73)=W5
3370 X(74)=W6
3375 X(75)=W7
3380 X(76)=S1(1)
3385 X(77)=S2(2)
3390 X(78)=S2(1)
3395 X(79)=S2(2)
3400 X(80)=S3(1)
3405 X(81)=S3(2)
3410 X(82)=S3(4)
3415 X(83)=S4(1)
3420 X(84)=S4(2)
3425 X(85)=S4(4)
3430 X(86)=S5(1)
3435 X(87)=S5(2)
3440 X(88)=S5(3)
3445 X(89)=S6(1)
3450 X(90)=S6(2)
3455 X(91)=S7(1)
3460 X(92)=S7(2)
3465 X(93)=S7(3)
3470 X(94)=V1
3475 X(95)=V2
3480 X(96)=V3(2)
3485 X(97)=V4(2)
3490 X(98)=V5(1)
3495 X(99)=V5
3500 X(100)=V6
3505 X(101)=V7
3510 X(102)=F1
3515 X(103)=F0
3520 X(104)=F0(1)
3525 X(105)=F0(2)
3530 X(106)=F0(3)
3535 X(107)=F0(4)
3540 X(108)=F0(5)
3545 X(109)=F0(6)
3550 X(110)=F0(7)
3555 X(111)=F0(8)
3560 X(112)=F0(9)
3565 X(113)=K8
3570 IF L=5 THEN X(114)=F0(12) ELSE X(114)=F0(10)
3575 IF L=5 THEN X(115)=0 ELSE X(115)=F0(11)
3580 X(116)=F2
3585 X(117)=F2(1)
3590 X(118)=F2(2)
3595 X(119)=F2(3)
3600 X(120)=F2(4)
3605 X(121)=F7
3610 X(122)=F8
3615 X(123)=F9(1)
3620 X(124)=F9(2)
3625 X(125)=F
3630 PRINT# 9,G0 ; X()
3635 RETURN
```

```
6000 ! CELL LIFE DATA
6002 U1(1),U1(2)=1
6004 FOR I=1 TO 18
6006 B(I)=(O(I)-O1)/U(I)*100000/U1(1)/U1(2)
6008 NEXT I
6010 RETURN
6025 ! CELL CURRENT DENSITY
6027 I=0
6029 I=I+1
6031 IF B(I)>B0 AND I#18 THEN 6029
6033 M=(B0-B(I))/(B(I-1)-B(I))*(M(I-1)-M(I))+M(I)
6035 IF I=18 THEN M=569
6040 RETURN
6050 ! CELL LIFE
6055 I=0
6060 I=I+1
6065 IF M0>M(I) THEN 6060
6070 X0=(M(I)-M0)/(M(I)-M(I-1))
6075 U=X0*(B(I-1)-B(I))+B(I)
6080 RETURN
6100 ! CELL VOLTAGE
6105 O0=X0*(O(I-1)-O(I))+O(I)
6110 U0=X0*(U(I-1)-U(I))+U(I)
6115 O=O0-U0*.00001*U1(1)*U1(2)*B0
6120 RETURN
6150 ! CELL HEAT LOAD
6155 I=0
6160 I=I+1
6165 IF H0>H0(I) THEN 6160
6170 U=(H0-H0(I-1))/(H0(I)-H0(I-1))*(U0(I)-U0(I-1))+U0(I-1)
6175 RETURN
6200 ! H2/O2 STORAGE TANKS
6210 A(1)=.59304-.00021233*A1
6211 A(2)=1.298+.012321*A1
6212 A(3)=1.1444+.057575*A1
6213 A(4)=2.1252+.21235*A1
6214 A(5)=4.2553+.34588*A1
6215 IF A0>303903 THEN 6240
6220 I=0
6221 I=I+1
6222 IF A0>A0(I) THEN 6221
6230 A=(A0-A0(I-1))/(A0(I)-A0(I-1))*(A(I)-A(I-1))+A(I-1)
6235 RETURN
6240 A0(1)=.62757+.000013104*A0
6241 A0(2)=37.136+.001072*A0
6242 A=(A1-1)/999*(A0(2)-A0(1))+A0(1)
6245 RETURN
```

```
1 !  "OUTPUT","TH",2
2 OPTION BASE 1
3 INTEGER G9,I
5 DIM X(9,96)
6 CLEAR @ DISP "DATA FILE";@ INPUT D$
7 ASSIGN# 9 TO D$
8 READ# 9 ; X(,)
9 ASSIGN# 9 TO *
10 G9=X(1,1) @ P0=X(4,1)
15 ON X(2,1) GOTO 20,25
20 A$="LEO" @ GOTO 30
25 A$="GEO" @ GOTO 30
30 ON X(3,1) GOTO 35,40,45
35 B$="(NiCd)" @ GOTO 50
40 B$="(NiH2)" @ GOTO 50
45 B$="(H2O2)" @ GOTO 50
50 ON KEY# 1,"CHART" GOSUB 100
55 ON KEY# 2,"TABLE" GOSUB 200
70 KEY LABEL
75 DISP "SELECT DESIRED OUTPUT"
80 GOTO 80
100 ! "CHART" SUBROUTINE
105 DIM F$[16]
110 F$="----------------"
115 GOSUB 5000
120 FOR I=1 TO G9
125 GOSUB 5500
130 NEXT I
135 RETURN
200 ! "TABLE" SUBROUTINE
205 GOSUB 6000
210 FOR I=1 TO IP(G9/3)
215 GOSUB 6500
220 NEXT I
225 IF INT(FP(G9/3)*3+.5)=0 THEN RETURN
230 IF INT(FP(G9/3)*3+.5)=1 THEN GOSUB 7000
235 IF INT(FP(G9/3)*3+.5)=2 THEN GOSUB 7500
240 RETURN
5000 ! "CHART" TITLES SUBROUTINE
5005 PRINT @ PRINT @ PRINT @ PRINT @ PRINT @ PRINT
5010 PRINT USING "3A,7X,9A,7X,6A" ; A$,VAL$(P0/1000)&"KW ESS",B$ @ PRINT @ PRINT @ PRINT
5015 PRINT "MISSION PARAMETERS" @ PRINT @ PRINT
5020 PRINT "1 Total Number of Battery Cycles" @ PRINT
5025 PRINT "2 Maximum Discharge Time (Hr)" @ PRINT
5030 PRINT "3 Minimum Charge Time (Hr)" @ PRINT
5035 PRINT "4 Total ESS Life (Yr)" @ PRINT
5040 PRINT "5 Number of Hardware Life Cycles" @ PRINT
5041 PRINT F$;F$ @ PRINT
5042 PRINT "ESS PERFORMANCE REQUIREMENTS" @ PRINT @ PRINT
5043 PRINT "1 Total Power Required (W)" @ PRINT
5044 PRINT "2 Total Voltage Required (V)" @ PRINT
5045 PRINT "3 Required Battery Life (Yr)" @ PRINT
5048 PRINT F$;F$ @ PRINT
5049 PRINT "ESS PERFORMANCE PARAMETERS" @ PRINT @ PRINT
5050 PRINT "1 Maximum Battery Life (Yr)" @ PRINT
5055 PRINT "2 Capacity Degradation Factor" @ PRINT
5060 PRINT "3 Voltage Degradation Factor" @ PRINT
5065 PRINT "4 EOL Minimum Power (W)" @ PRINT
5070 PRINT "5 EOL Minimum Voltage (V)" @ PRINT
5073 PRINT F$;F$ @ PRINT
5075 PRINT "BATTERY CELL QUANTITIES" @ PRINT @ PRINT
5080 PRINT "1 Total Number of Cells" @ PRINT
```

```
5085 PRINT "2 Total Cells in Parallel" @ PRINT
5090 PRINT "3 Total Cells in Series" @ PRINT
5095 PRINT "4 Number of Modules/Battery" @ PRINT
5100 PRINT "5 Number of Cells/Module (Avg)" @ PRINT
5103 PRINT F$;F$ @ PRINT
5105 PRINT "BATTERY CELL DISCHARGE            PARAMETERS" @ PRINT @ PRINT
5110 PRINT "1 Rated Cell Capacity (AH)" @ PRINT
5115 PRINT "2 EOL Max. Depth of Discharge" @ PRINT
5120 PRINT "3 EOL Max. Discharge (AH)" @ PRINT
5125 PRINT "4 Max. Discharge Current (A)" @ PRINT
5130 PRINT "5 EOL Min. Voltage (V)" @ PRINT
5133 PRINT F$;F$ @ PRINT
5135 PRINT "BATTERY CELL CHARGE PARAMETERS" @ PRINT @ PRINT
5140 PRINT "1 Recharge Fraction" @ PRINT
5145 PRINT "2 Charge Throughput" @ PRINT
5150 PRINT "3 Charge Current (A)" @ PRINT
5155 PRINT "4 Charge Voltage (V)" @ PRINT
5160 PRINT "5 Watt-Hour Efficiency" @ PRINT
5163 PRINT F$;F$ @ PRINT
5165 PRINT "ESS THERMAL PARAMETERS" @ PRINT @ PRINT
5170 PRINT "1 Average Operating Temperature    (Deg-K)" @ PRINT
5175 PRINT "2 Battery Cell Enthalpy Voltage    (V)" @ PRINT
5180 PRINT "3 Maximum Discharge Heat Load      (W)" @ PRINT
5185 PRINT "4 Maximum Chage Heat Load (W)" @ PRINT
5190 PRINT "5 Maximum Cycle Heat Load (W)" @ PRINT
5193 PRINT F$;F$ @ PRINT
5195 PRINT "ESS INTERFACE PARAMETERS" @ PRINT @ PRINT
5200 PRINT "1 Max Solar Array Power (W)" @ PRINT
5205 PRINT "2 Max Solar Array Weight (Kg)" @ PRINT
5215 PRINT "3 Max Thermal Control Weight       (Kg)" @ PRINT
5223 PRINT F$;F$ @ PRINT
5225 PRINT "WEIGHTS (Kg)" @ PRINT @ PRINT
5230 PRINT "1 Battery Cell (incl terminals)" @ PRINT
5235 PRINT "2 Battery Module (Avg)" @ PRINT
5240 PRINT "3 BRPC" @ PRINT
5245 PRINT "4 Charger (p3)" @ PRINT
5250 PRINT "5 Channel (less interfaces)" @ PRINT
5255 PRINT "6 Channel Interfaces" @ PRINT
5260 PRINT "7 ESS (incl Interfaces)" @ PRINT
5263 PRINT F$;F$ @ PRINT
5265 PRINT "DIMENSIONS (CM)" @ PRINT @ PRINT
5268 IF B$="(NICd)" THEN PRINT "1 Battery Cell (incl terminals)     (LxWxH)" @ PRINT
5270 IF B$="(NIH2)" THEN PRINT "1 Battery Cell (incl terminals)     (DiaxL)" @ PRINT
5275 PRINT "2 Large Battery Module (LxWxH)" @ PRINT
5276 PRINT "3 Small Battery Module (LxWxH)" @ PRINT
5277 PRINT "4 BRPC (LxWxH)" @ PRINT
5278 PRINT "5 Charger (p3) (LxWxH)" @ PRINT
5279 PRINT "6 Channel  (LxWxH)" @ PRINT
5280 PRINT "7 ESS (LxDxS)" @ PRINT
5281 PRINT F$;F$ @ PRINT
5290 PRINT "VOLUMES (cm3)" @ PRINT @ PRINT
5291 PRINT "1 Battery Cell (incl terminals)" @ PRINT
5292 PRINT "2 Large Battery Module" @ PRINT
5293 PRINT "3 Small Battery Module" @ PRINT
5294 PRINT "4 BRPC" @ PRINT
5295 PRINT "5 Charger (p3)" @ PRINT
5296 PRINT "6 Channel (less Interfaces)" @ PRINT
5297 PRINT "7 ESS (incl Interfaces)" @ PRINT
5298 PRINT F$;F$ @ PRINT
5305 PRINT "LIFE CYCLE COSTS (1980$M)" @ PRINT
5310 PRINT " DDT&E" @ PRINT
5315 PRINT " PRODUCTION" @ PRINT
```

```
5318 PRINT "a Battery Cell" @ PRINT
5320 PRINT "1 Cell Matching" @ PRINT
5325 PRINT "2 Module Assembly" @ PRINT
5330 PRINT "3 Channel Assembly" @ PRINT
5335 PRINT "4 Subsystem Assembly" @ PRINT
5340 PRINT "5 Acceptance & Surface Transport" @ PRINT
5345 PRINT "6 Prelaunch Integration &          Checkout" @ PRINT
5350 PRINT "7 Space Transport" @ PRINT
5355 PRINT "8 Space Deployment & Checkout" @ PRINT
5360 PRINT " OPERATIONS & MAINTENANCE" @ PRINT
5365 PRINT "1 Spares Production" @ PRINT
5370 PRINT "2 Crew Training" @ PRINT
5375 PRINT "3 Labor" @ PRINT
5380 PRINT "4 Space Transport" @ PRINT @ PRINT
5383 PRINT "ESS LIFE CYCLE COST" @ PRINT @ PRINT
5385 PRINT " INTERFACE COSTS" @ PRINT
5387 PRINT "1 Solar Array" @ PRINT
5389 PRINT "2 Thermal Control" @ PRINT
5390 PRINT "3 Power Conditioning" @ PRINT @ PRINT
5392 PRINT "TOTAL LIFE CYCLE COST " @ PRINT @ PRINT @ PRINT @ PRINT @ PRINT @ PRINT @ PRINT
5395 RETURN
```

```
1 ! "Output","FM",2
2 OPTION BASE 1
3 INTEGER G9,I,J
5 DIM X(9,128)
6 CLEAR @ DISP "DATA FILE ";@ INPUT D$
7 ASSIGN# 9 TO D$
8 READ# 9 ; X(,)
9 ASSIGN# 9 TO *
10 G9=X(1,1) @ P0=X(4,1)
15 ON X(2,1) GOTO 20,25
20 A$="LEO" @ GOTO 45
25 A$="GEO"
45 B$="(H202)"
50 ON KEY# 1,"CHART" GOSUB 100
55 ON KEY# 2,"TABLE" GOSUB 200
70 KEY LABEL
75 DISP "SELECT DESIRED OUTPUT"
80 GOTO 80
100 ! "CHART" SUBROUTINE
105 DIM F$[16]
110 F$="----------------"
115 GOSUB 5000
120 FOR I=1 TO G9
125 GOSUB 5500
130 NEXT I
135 RETURN
200 ! "TABLE" SUBROUTINE
205 GOSUB 6000
210 FOR I=1 TO IP(G9/3)
215 GOSUB 6500
220 NEXT I
225 IF INT(FP(G9/3)*3+.5)=0 THEN RETURN
230 IF INT(FP(G9/3)*3+.5)=1 THEN GOSUB 7000
235 IF INT(FP(G9/3)*3+.5)=2 THEN GOSUB 7500
240 RETURN
5000 ! "CHART" TITLES SUBROUTINE
5005 PRINT @ PRINT @ PRINT @ PRINT @ PRINT @ PRINT
5010 PRINT USING "3A,7X,9A,7X,6A" ; A$,VAL$(P0/1000)&"KW ESS",B$ @ PRINT @ PRINT @ PRINT
5015 PRINT "MISSION PARAMETERS" @ PRINT @ PRINT
5020 PRINT "1 Total Number of ESS Cycles" @ PRINT
5025 PRINT "2 Maximum Dark Period (Hr)" @ PRINT
5030 PRINT "3 Minimum Light Period (Hr)" @ PRINT
5035 PRINT "4 Total ESS Life (Hr)" @ PRINT
5040 PRINT "5 Number of FCU Maintenance          Cycles" @ PRINT
5041 PRINT "6 Number of ECU Maintenance          Cycles" @ PRINT
5042 PRINT "7 Number of Pump Maintenance         Cycles" @ PRINT
5043 PRINT F$;F$ @ PRINT
5044 PRINT "ESS PERFORMANCE REQUIREMENTS" @ PRINT @ PRINT
5045 PRINT "1 Total Power Required (W)" @ PRINT
5046 PRINT "2 Total Voltage Required (V)" @ PRINT
5047 PRINT "3 Required FCU Life (Hr)" @ PRINT
5048 PRINT "4 Required ECU Life (Hr)" @ PRINT
5049 PRINT "5 Required Pump Life (Hr)" @ PRINT
5050 PRINT F$;F$ @ PRINT
5053 PRINT "ESS PERFORMANCE PARAMETERS" @ PRINT @ PRINT
5054 PRINT "1 EOL Minimum Power (W)" @ PRINT
5055 PRINT "2 EOL Minimum Voltage (V)" @ PRINT
5060 PRINT "3 Maximum FCU Life (Hr)" @ PRINT
5065 PRINT "4 Maximum ECU Life (Hr)" @ PRINT
5070 PRINT "5 Maximum Pump Life (Hr)" @ PRINT
5071 PRINT "6 Number of ESS Sides" @ PRINT
5072 PRINT "7 Number of ESS Channels" @ PRINT
```

```
5073 PRINT F$;F$ @ PRINT
5075 PRINT "FUEL CELL UNIT QUANTITIES" @ PRINT @ PRINT
5080 PRINT "1 Total Number of FCU" @ PRINT
5085 PRINT "2 Total Parallel FCU" @ PRINT
5090 PRINT "3 Total Series FCU" @ PRINT
5095 PRINT "4 Number of FC Stacks" @ PRINT
5100 PRINT "5 Number of FCU/FC Stack (Avg)" @ PRINT
5103 PRINT F$;F$ @ PRINT
5105 PRINT "FUEL CELL UNIT PERFORMANCE        PARAMETERS" @ PRINT @ PRINT
5110 PRINT "1 EOL Min. Dark Period Power          (W)" @ PRINT
5115 PRINT "2 EOL Min. Dark Period Voltage        (V)" @ PRINT
5120 PRINT "3 Active Cell Area (cm3)" @ PRINT
5125 PRINT "4 EOL Dark Period Current             Density (Ma/cm)" @ PRINT
5130 PRINT "5 EOL Light Period Current            Density (Ma/cm)" @ PRINT
5133 PRINT F$;F$ @ PRINT
5135 PRINT "ELECTROLYSIS CELL UNIT                QUANTITIES" @ PRINT @ PRINT
5136 PRINT "1 Total Number of ECU" @ PRINT
5137 PRINT "2 Total Parallel ECU" @ PRINT
5138 PRINT "3 Total Series FCU" @ PRINT
5139 PRINT "4 Number of EC Stacks" @ PRINT
5140PRINT "5 Number of ECU/EC Stack (Avg)" @ PRINT
5145 PRINT F$;F$ @ PRINT
5150 PRINT "ELECTROLYSIS CELL UNIT                PERFORMANCE PARAMETERS" @ PRINT @ PRINT
5151 PRINT "1 EOL Max. Light Period Power         (W)" @ PRINT
5152 PRINT "2 EOL Max. Light Period Voltage       (V)" @ PRINT
5153 PRINT "3 Active Cell Area (cm3)" @ PRINT
5155 PRINT "4 EOL Dark Period Current             Density (Ma/cm)" @ PRINT
5160 PRINT "5 EOL Light Period Current            Density (Ma/cm)" @ PRINT
5163 PRINT F$;F$ @ PRINT
5165 PRINT "ESS THERMAL PARAMETERS" @ PRINT @ PRINT
5166 PRINT "1 FCU Average Operating Pressure      (Kg/cm2)" @ PRINT
5167 PRINT "2 FCU Average Operating               Temperature (Deg-K)" @ PRINT
5168 PRINT "3 ECU Average Operating Pressure      (Kg/cm2)" @ PRINT
5169 PRINT "4 ECU Average Operating               Temperature (Deg-K)" @ PRINT
5170 PRINT "5 Maximum Dark Period Heat Load       (W)" @ PRINT
5171 PRINT "6 Maximum Light Period Heat Load      (W)" @ PRINT
5172 PRINT "7 Maximum Cycle Heat Load (W)" @ PRINT
5173 PRINT F$;F$ @ PRINT
5175 PRINT "TOTAL ESS PARAMETERS" @ PRINT @ PRINT
5176 PRINT "1 Watt-Hour Efficiency" @ PRINT
5177 PRINT "2 DoD Factor" @ PRINT
5178 PRINT "3 Storage Temperature (Deg-K)" @ PRINT
5179 PRINT "4 H2 Storage Pressure (Kg/cm2)" @ PRINT
5180 PRINT "5 H2 Storage Volume (cm3)" @ PRINT
5181 PRINT "6 H2 Storage Weight (Kg)" @ PRINT
5182 PRINT "7 H2 Storage Tank Weight (Kg)" @ PRINT
5183 PRINT "8 O2 Storage Pressure (Kg/cm2)" @ PRINT
5184 PRINT "9 O2 Storage Volume (cm3)" @ PRINT
5185 PRINT "10 O2 Storage Weight (Kg)" @ PRINT
5186 PRINT "11 O2 Storage Tank Weight (Kg)" @ PRINT
5187 PRINT "12 H2O Storage Pressure (Kg/cm2)" @ PRINT
5188 PRINT "13 H2O Storage Volume (cm3)" @ PRINT
5189 PRINT "14 H2O Storage Weight (Kg)" @ PRINT
5190 PRINT "15 H2O Storage Tank Weight (Kg)" @ PRINT
5191 PRINT F$;F$ @ PRINT
5195 PRINT "ESS INTERFACE PARAMETERS" @ PRINT @ PRINT
5200 PRINT "1 Max Solar Array Power (W)" @ PRINT
5205 PRINT "2 Max Solar Array Voltage (V)" @ PRINT
5210 PRINT "3 Max Solar Array Weight (Kg)" @ PRINT
5215 PRINT "4 Max Thermal Control Weight          (Kg)" @ PRINT
5220 PRINT "5 Max Power Conditioning Weight       (Kg)" @ PRINT
5223 PRINT F$;F$ @ PRINT
```

```
5225 PRINT "WEIGHTS (Kg)" @ PRINT @ PRINT
5230 PRINT "1 FCU" @ PRINT
5231 PRINT "2 ECU" @ PRINT
5235 PRINT "3 FC Stack (Avg)" @ PRINT
5240 PRINT "4 EC Stack (Avg)" @ PRINT
5245 PRINT "5 Charger (p3)" @ PRINT
5250 PRINT "6 Power Module" @ PRINT
5255 PRINT "7 Ancilliary Equipment" @ PRINT
5260 PRINT "8 ESS (incl Interfaces)" @ PRINT
5263 PRINT F$;F$ @ PRINT
5265 PRINT "DIMENSIONS (cm)" @ PRINT @ PRINT
5268 PRINT "1 FCU (Active Area)        (LxW)" @ PRINT
5270 PRINT "2 ECU (Active Area)        (LxW)" @ PRINT
5275 PRINT "3 FC Stack (Max)          (LxWxH)" @ PRINT
5276 PRINT "4 EC Stack (Max)          (LxWxH)" @ PRINT
5277 PRINT "5 Charger (p3)            (LxWxH)" @ PRINT
5278 PRINT "6 Power Module            (LxWxH)" @ PRINT
5279 PRINT "7 Ancilliary Equipment     (DiaxL)" @ PRINT
5280 PRIT "8·ESS                     (LxDxS)" @ PRINT
5281 PRINT F$;F$ @ PRINT
5290 PRINT "VOLUMES (cm3)" @ PRINT @ PRINT
5291 PRINT "1 FCU" @ PRINT
5292 PRINT "2 ECU" @ PRINT
5293 PRINT "3 FC Stack" @ PRINT
5294 PRINT "4 EC Stack" @ PRINT
5295 PRINT "5 Charger (p3)" @ PRINT
5296 PRINT "6 Power Module" @ PRINT
5297 PRINT "7 Ancilliary Equipment" @ PRINT
5298 PRINT "8 ESS (incl Interfaces)" @ PRINT
5299 PRINT F$;F$ @ PRINT
5305 PRINT "LIFE CYCLE COSTS (1980$M)" @ PRINT
5310 PRINT " DDT&E" @ PRINT
5315 PRINT " PRODUCTION" @ PRINT
5320 PRINT "a FCU" @ PRINT
5321 PRINT "b ECU" @ PRINT
5322 PRINT "1 FC Stack" @ PRINT
5323 PRINT "2 EC Stack" @ PRINT
5325 PRINT "3 Power Module Assembly" @ PRINT
5330 PRINT "4 Ancilliary Equipment" @ PRINT
5335 PRINT "5 Subsystem Assembly" @ PRINT
5340 PRINT "6 Acceptance & Surface Transport" @ PRINT
5345 PRINT "7 Prelaunch Integration &          Checkout" @ PRINT
5350 PRINT "8 Space Transport" @ PRINT
5355 PRINT "9 Space Deployment & Checkout" @ PRINT
5360 PRINT " OPERATIONS & MAINTENANCE" @ PRINT
5365 PRINT "1 Spares Production" @ PRINT
5370 PRINT "2 Crew Training" @ PRINT
5375 PRINT "3 Labor" @ PRINT
5380 PRINT "4 Space Transport" @ PRINT @ PRINT
5383 PRINT "ESS LIFE CYCLE COST" @ PRINT @ PRINT
5385 PRINT " INTERFACE COSTS" @ PRINT
5387 PRINT "1 Solar Array" @ PRINT
5388 PRINT "2 Thermal Control" @ PRINT
5389 PRINT "3 Power Conditioning" @ PRINT @ PRINT
5390 PRINT "TOTAL LIFE CYCLE COST " @ PRINT @ PRINT @ PRINT @ PRINT @ PRINT @ PRINT @ PRINT
5395 RETURN
5500 ! "CHART" DATA SUBROUTINE
5505 PRINT USING 5605 ; X(1,2),X(1,3),X(1,4),X(1,5),X(1,6),X(1,7),X(1,8),F$,F$
5510 PRINT USING 5610 ; X(1,9),X(1,10),X(1,11),X(1,12),X(1,13),F$,F$
5515 PRINT USING 5615 ; X(1,14),X(1,15),X(1,16),X(1,17),X(1,18),X(1,19),X(1,20),F$,F$
5520 PRINT USING 5610 ; X(1,21),X(1,22),X(1,23),X(1,24),X(1,25),F$,F$
5525 PRINT USING 5625 ; X(1,26),X(1,27),X(1,28),X(1,29),X(1,30),F$,F$
```

```
5530 PRINT USING 5630 ; X(1,31),X(1,32),X(1,33),X(1,34),X(1,35),F$,F$
5535 PRINT USING 5625 ; X(1,36),X(1,37),X(1,38),X(1,39),X(1,40),F$,F$
5540 PRINT USING 5640 ; X(1,41),X(1,42),X(1,43),X(1,44),X(1,45),X(1,46),X(1,47),F$,F$
5545 PRINT USING 5645 ; X(1,48),X(1,49),X(1,50),X(1,51),X(1,52),X(1,53),X(1,54),X(1,55)
5550 PRINT USING 5650 ; X(1,56),X(1,57),X(1,58),X(1,59),X(1,60),X(1,61),X(1,62),F$,F$
5555 PRINT USING 5655 ; X(1,63),X(1,64),X(1,65),X(1,66),X(1,67),F$,F$
5558 IF X(1,113)=1 THEN W$="(*)" @ V$="" ELSE W$="" @ V$="(*)"
5560 PRINT USING 5660 ; X(1,68),X(1,69),X(1,70),X(1,71),X(1,72),X(1,73),X(1,74),X(1,75),W$,F$,F$
5565 PRINT USING 5665 ; X(1,76),X(1,77),X(1,78),X(1,79),X(1,80),X(1,81),X(1,82)
5570 PRINT USING 5670 ; X(1,83),X(1,84),X(1,85),63.5,26.9,16.5
5572 PRINT USING 5672 ; X(1,86),X(1,87),X(1,88),X(1,89),X(1,90)
5575 PRINT USING 5675 ; V$,X(1,91),X(1,92),X(1,93),F$,F$
5580 PRINT USING 5680 ; X(1,94),X(1,95),X(1,96),X(1,97),X(1,98),X(1,99),X(1,100),X(1,101),F$,F$
5585 PRINT USING 5685 ; X(1,102),X(1,103),"(",X(1,104),")","(",X(1,105),")",X(1,106),X(1,107)
5587 PRINT USING 687 ; X(1,108),X(1,109),X(1,110),X(1,111),X(1,112),X(1,114),X(1,115)
5590 PRINT USING 5690 ; X(1,116),X(1,117),X(1,118),X(1,119),X(1,120)
5595 PRINT USING 5695 ; X(1,121),X(1,122),X(1,123),X(1,124),X(1,125)
5605 IMAGE 4/,14X,K,//,14X,K,//,14X,K,//,14X,K,//,14X,K,3/,14X,K,3/,14X,K,3/,K,K
5610 IMAGE 4/,14X,K,//,14X,K,//,14X,K,//,14X,K,//,14X,K,//,K,K
5615 IMAGE 4/,14X,K,//,14X,K,//,14X,K,//,14X,K,//,14X,K,//,14X,K,//,14X,K,//,K,K
5625 IMAGE 5/,14X,K,3/,14X,K,3/,14X,K,//,14X,K,3/,14X,K,3/,K,K
5630 IMAGE 5/,14X,K,//,14X,K,//,14X,K,//,14X,K,//,14X,K,//,K,K
5640 IMAGE 4/,14X,K,3/,14X,K,3/,14X,K,3/,14X,K,3/,14X,K,3/,14X,K,3/,14X,K,//,K,K
5645 IMAGE 4/,14X,K,//,14X,K,//,14X,K,//,14X,K,//,14X,K,//,14X,K,//,14X,K,//,14X,K,//
5650 IMAGE 14X,K,//,14X,K,//,14X,K,//,14X,K,//,14X,K,//,14X,K,//,14X,K,//,K,K
5655 IMAGE 4/,14X,K,//,14X,K,//,14X,K,//,14X,K,3/,14X,K,3/,K,K
5660 IMAGE 4/,14X,K,//,14X,K,//,14X,K,//,14X,K,//,14X,K,//,14X,K,//,14X,K,X,3A,//,K,K
5665 IMAGE 4/,10X,3D.2D,X,"x",2D.2D,//,10X,3D.2D,X,"x",2D.2D,//,3X,4D.2D,X,"x",4D.2D,X,"x",4D.2D
5670 IMAGE /,3X,4D.2D,X,"x",4D.2D,X,"x",4D.2D,//,3X,4D.2D,X,"x",4D.2D,X,"x",4D.2D,//
5672 IMAGE 3X,4D.2D,X,"x",4D.2D,X,"x",4D.2D,//,8X,4D.2D,X,"x",4D.2D,//
5675 IMAGE 3X,4D.2D,X,"x",4D.2D,X,"x",4D.2D,//,K,K
5680 IMAGE 4/,14X,K,//,14X,K,//,14X,K,//,14X,K,//,14X,K,//,14X,K,//,14X,K,//,K,K
5685 IMAGE 3/,18X,5D.3D,//,18X,5D.3D,//,6X,A,D.3D,A,//,6X,A,D.3D,A,//,4X,4D.3D,//4X,4D.3D,//
5687 IMAGE 4X,4D.3D,//,4X,4D.3D,//,4X,4D.3D,//4X,4D.3D,//,4X,4D.3D,3/,4X,4D.3D,//4X,4D.3D,//
5690 IMAGE 18X,5D.3D,//,4X,4D.3D,//,4X,4D.3D,//,4X,4D.3D,//,4X,4D.3D,3/
5695 IMAGE 18X,5D.3D,5/,4X,4D.3D,//,4X,4D.3D,//,4X,4D.3D,3/,18X,5D.3D,8/
5700 RETURN
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This appendix contains data printouts and curves which are discussed in Section 4.0 of the main body of the Electrochemical Energy Storage Subsystems Final Report. The exhibits contained herein are as follows:

	NiCd Battery Parameter	Appendix G Exhibit #'s
1.	Depth of Discharge (Capacity Variable)	1 [A - E]
2.	Cell Life (Capacity Variable)	2 [A - E]
3.	Depth of Discharge (Capacity Fixed)	3 [A - E]
4.	Cell Life (Capacity Fixed)	4 [A - E]
5.	Rated Cell Capacity	5 [A - E]
6.	Hardware Life Cycles (Capacity Variable)	6 [A - D]
7.	Discharge Current (Capacity Variable)	7 [A - E]
8.	Hardware Life Cycles (Capacity Variable)	8 [A - D]
	NiH_2 Battery Parameter	
1.	Depth of Discharge (Capacity Variable)	9 [A - E]
2.	Cell Life (Capacity Variable)	10 [A - E]
3.	Depth of Discharge (Capacity Fixed)	11 [A - E]
4.	Cell Life (Capacity Fixed)	12 [A - E]
5.	Rated Cell Capacity	13 [A - E]
6.	Hardware Life Cycles (Capacity Variable)	14 [A - D]
7.	Discharge Current (Capacity Variable)	15 [A - E]
8.	Hardware Life Cycles (Capacity Fixed)	16 [A - D]
	Fuel Cell Parameter	
1.	FCU Current Density	17 [A - E]
2.	FCU Voltage	18 [A - E]
3.	FCU Active Area	19 [A - E]
4.	FCU Life	20 [A - D]
5.	FCU Hardware Life Cycles	21 [A - D]

LEO 25KW ESS (NiCd)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	3	3	4	4	5	7	9	12	18
Maximum Battery Life (Yr)	10.025	9.225	8.265	7.053	5.754	4.467	3.318	2.368	1.602
Rated Cell Capacity (AH)	135	95	70	55	45	40	35	30	30
Maximum Depth of Discharge	.100	.150	.200	.250	.300	.350	.400	.450	.500
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	19.486	20.382	20.401	19.709	19.393	20.289	20.193	19.365	21.553
Minimum Voltage (V)	1.181	1.144	1.147	1.112	1.098	1.094	1.075	1.060	1.052
Recharge Fraction	1.187	1.122	1.081	1.057	1.035	1.014	1.005	1.005	1.005
Charge Current (A)	15.875	15.708	15.136	14.304	13.783	14.125	13.927	13.357	14.865
Charge Voltage (V)	1.606	1.636	1.620	1.660	1.669	1.665	1.685	1.709	1.745
Watt-Hour Efficiency	.620	.623	.655	.634	.636	.648	.635	.617	.600
PHYSICAL CHARACTERISTICS									
Total Number of Cells	1320	1356	1356	1392	1416	1416	1440	1464	1476
Number of Parallel Batteries	12	12	12	12	12	12	12	12	12
Number of Modules per Battery	8	8	8	6	6	6	6	6	6
Battery Cell Weight (Kg)	5.377	3.801	2.816	2.224	1.830	1.633	1.436	1.239	1.239
Battery Cell Volume (Cm^3)	1966	1384	1015	800	654	578	507	434	434
ESS Weight (Kg)	8100	6034	4592	3811	3268	2969	2712	2442	2486
ESS Volume (M^3)	37.874	37.874	37.874	22.491	22.491	22.491	22.491	15.681	15.681
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	14.906	12.898	11.505	10.771	10.258	9.962	9.723	9.468	9.509
Production Cost	31.734	25.020	20.394	17.941	16.247	15.305	14.520	13.695	13.827
Operations & Maintenance Cost	107.704	97.013	121.757	96.095	116.456	160.708	203.033	265.062	400.206
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ESS LIFE CYCLE COST	154.344	134.931	153.656	124.807	142.961	185.975	227.276	288.225	423.542
Solar Array Cost	239.630	246.499	237.317	236.261	233.466	237.682	240.523	238.335	265.848
Thermal Control Cost	7.694	7.633	7.157	7.254	7.125	6.988	7.058	7.148	7.555
Power Conditioning Cost	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645
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TOTAL LIFE CYCLE COST	403.313	390.703	399.775	369.967	385.197	432.290	476.502	535.353	698.590

Exhibit 1a. Depth of Discharge (Capacity Variable)

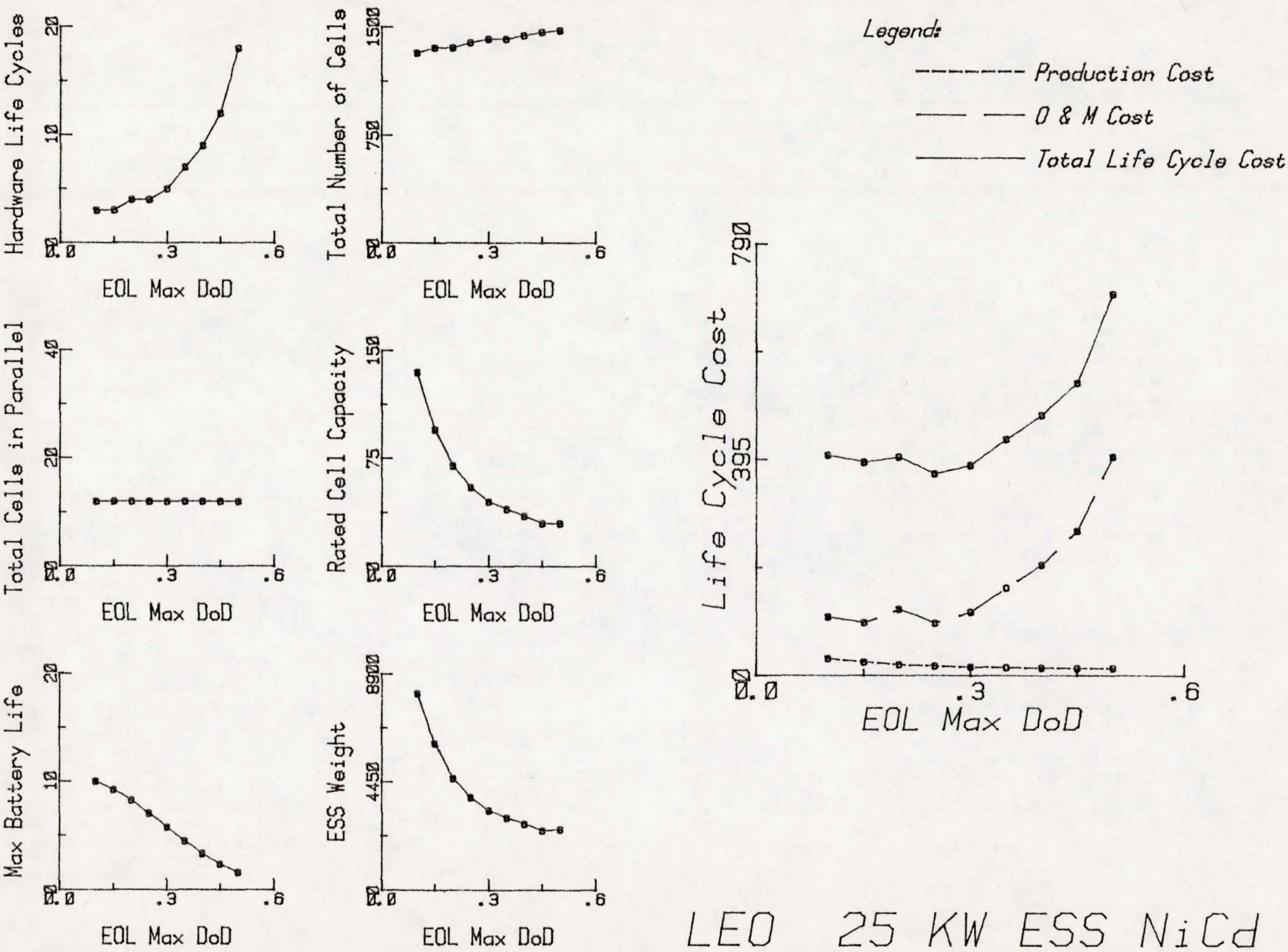

Exhibit 1a. Depth of Discharge (Capacity Variable) Continued

LEO 50KW ESS (NiCd)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	3	3	4	4	5	7	9	12	18
Maximum Battery Life (Yr)	10.025	9.225	8.265	7.053	5.754	4.467	3.318	2.368	1.602
Rated Cell Capacity (AH)	270	185	135	110	90	80	70	60	55
Maximum Depth of Discharge	.100	.150	.200	.250	.300	.350	.400	.450	.500
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	38.971	39.689	39.345	39.418	38.786	40.578	40.384	38.732	39.515
Minimum Voltage (V)	1.181	1.144	1.147	1.112	1.098	1.094	1.076	1.060	1.052
Recharge Fraction	1.187	1.122	1.081	1.057	1.035	1.014	1.005	1.005	1.005
Charge Current (A)	31.751	30.587	29.191	28.605	27.564	28.249	27.853	26.714	27.255
Charge Voltage (V)	1.606	1.636	1.620	1.660	1.669	1.665	1.685	1.709	1.745
Watt-Hour Efficiency	.620	.623	.655	.634	.636	.648	.635	.617	.600
PHYSICAL CHARACTERISTICS									
Total Number of Cells	1320	1356	1356	1392	1416	1416	1440	1464	1476
Number of Parallel Batteries	12	12	12	12	12	12	12	12	12
Number of Modules per Battery	12	10	8	8	8	8	8	8	8
Battery Cell Weight (Kg)	10.698	7.348	5.377	4.392	3.604	3.210	2.816	2.422	2.224
Battery Cell Volume (Cm^3)	3946	2694	1966	1604	1313	1164	1015	872	800
ESS Weight (Kg)	15843	11384	8468	7230	6141	5545	5028	4486	4230
ESS Volume (M^3)	79.465	67.147	37.874	37.874	37.874	37.874	37.874	28.107	28.107
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	21.373	16.864	14.104	12.956	11.973	11.429	10.969	10.490	10.251
Production Cost	57.676	42.476	32.844	28.807	25.308	23.392	21.754	20.043	19.224
Operations & Maintenance Cost	180.036	139.696	150.326	140.720	168.069	230.289	288.324	372.376	550.296
ESS LIFE CYCLE COST	259.085	199.036	197.274	182.483	205.350	265.110	321.047	402.909	579.771
Solar Array Cost	413.098	420.942	402.144	412.149	407.321	414.666	419.623	415.830	432.559
Thermal Control Cost	10.188	9.938	8.975	9.303	9.049	8.773	8.914	9.095	9.519
Power Conditioning Cost	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645
TOTAL LIFE CYCLE COST	689.016	631.561	610.038	605.580	623.365	690.194	751.229	829.479	1023.494

Exhibit 1b. Depth of Discharge (Capacity Variable)

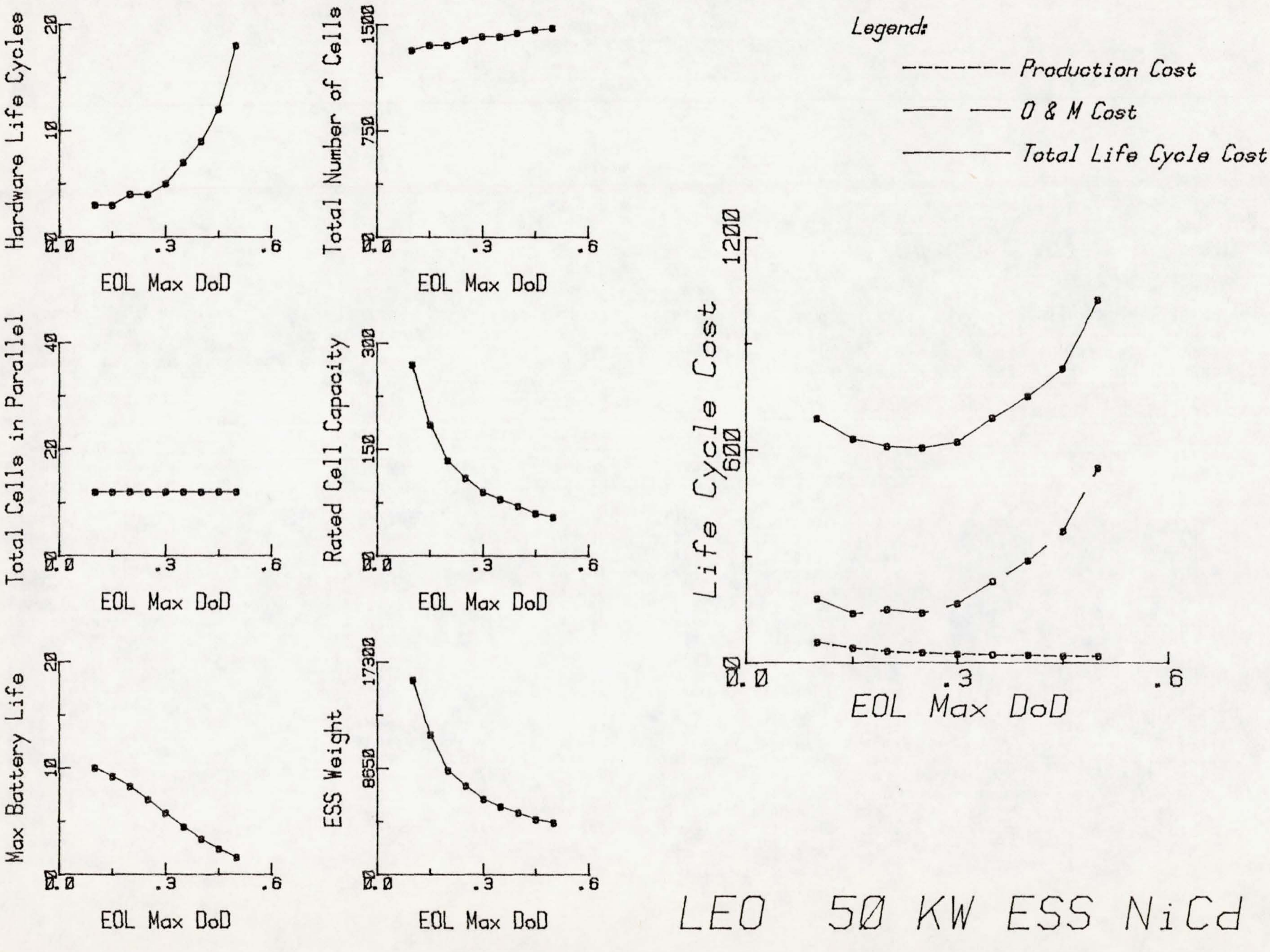

Exhibit 1b. Depth of Discharge (Capacity Variable) Continued

LEO 100KW ESS (NiCd)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	3	3	4	4	5	7	9	12	18
Maximum Battery Life (Yr)	10.025	9.225	8.265	7.053	5.754	4.467	3.318	2.368	1.602
Rated Cell Capacity (AH)	535	365	265	220	180	155	135	120	110
Maximum Depth of Discharge	.100	.150	.200	.250	.300	.350	.400	.450	.500
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	77.221	78.307	77.231	78.836	77.571	78.618	77.884	77.463	79.027
Minimum Voltage (V)	1.181	1.144	1.147	1.112	1.098	1.094	1.076	1.060	1.052
Recharge Fraction	1.187	1.122	1.081	1.057	1.035	1.014	1.005	1.005	1.005
Charge Current (A)	62.915	60.348	57.297	57.210	55.126	54.731	53.718	53.427	54.506
Charge Voltage (V)	1.606	1.636	1.620	1.660	1.669	1.665	1.685	1.709	1.745
Watt-Hour Efficiency	.620	.623	.655	.634	.636	.648	.635	.617	.600
PHYSICAL CHARACTERISTICS									
Total Number of Cells	1320	1356	1356	1392	1416	1416	1440	1464	1476
Number of Parallel Batteries	12	12	12	12	12	12	12	12	12
Number of Modules per Battery	16	16	12	12	12	12	8	8	8
Battery Cell Weight (Kg)	21.141	14.442	10.501	8.727	7.151	6.165	5.377	4.786	4.392
Battery Cell Volume (Cm^3)	7831	5327	3866	3217	2630	2266	1966	1746	1604
ESS Weight (Kg)	31098	22228	16335	14156	11973	10463	9303	8544	8031
ESS Volume (M^3)	156.160	156.160	79.465	79.465	79.465	79.465	37.874	37.874	37.874
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	36.732	26.254	20.215	18.029	15.988	14.620	13.606	12.926	12.453
Production Cost	112.584	79.613	59.021	51.479	44.147	39.146	35.365	32.869	31.164
Operations & Maintenance Cost	301.202	245.897	251.757	233.356	274.741	369.214	368.576	475.121	696.405
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ESS LIFE CYCLE COST	450.518	351.764	330.993	302.864	334.876	422.980	417.547	520.916	740.022
Solar Array Cost	724.090	726.454	691.126	719.071	710.646	705.276	711.097	725.517	754.633
Thermal Control Cost	15.084	14.548	12.606	13.405	12.897	12.122	12.364	12.989	13.835
Power Conditioning Cost	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645
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TOTAL LIFE CYCLE COST	1191.337	1094.411	1036.370	1036.985	1060.064	1142.023	1142.653	1261.067	1510.135

Exhibit 1c. Depth of Discharge (Capacity Variable)

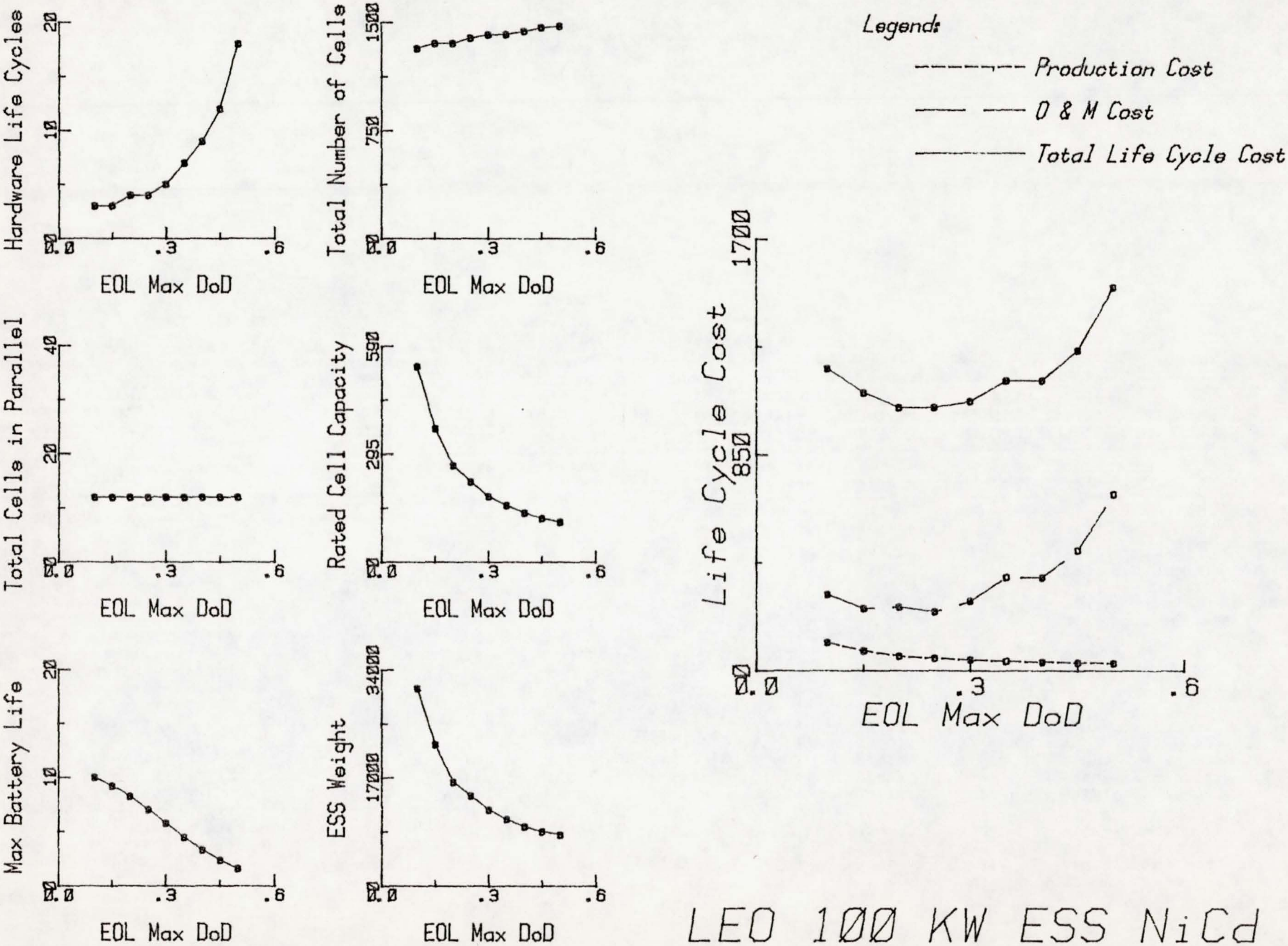

Exhibit 1c. Depth of Discharge (Capacity Variable) Continued

LEO 250KW ESS (NiCd)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	3	3	4	4	5	7	9	12	18
Maximum Battery Life (Yr)	10.025	9.225	8.265	7.053	5.754	4.467	3.318	2.368	1.602
Rated Cell Capacity (AH)	670	455	335	275	225	195	170	150	135
Maximum Depth of Discharge	.100	.150	.200	.250	.300	.350	.400	.450	.500
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	96.706	97.614	97.632	98.544	96.965	98.907	98.074	96.828	96.989
Minimum Voltage (V)	1.181	1.144	1.147	1.112	1.098	1.094	1.076	1.060	1.052
Recharge Fraction	1.187	1.122	1.081	1.057	1.035	1.014	1.005	1.005	1.005
Charge Current (A)	78.791	75.227	72.432	71.512	68.909	68.855	67.643	66.783	66.894
Charge Voltage (V)	1.606	1.636	1.620	1.660	1.669	1.665	1.685	1.709	1.745
Watt-Hour Efficiency	.620	.623	.655	.634	.636	.648	.635	.617	.600
PHYSICAL CHARACTERISTICS									
Total Number of Cells	2640	2712	2712	2784	2832	2832	2880	2928	2952
Number of Parallel Batteries	24	24	24	24	24	24	24	24	24
Number of Modules per Battery	16	16	14	12	12	12	12	12	8
Battery Cell Weight (Kg)	26.462	17.988	13.259	10.895	8.924	7.742	6.757	5.968	5.377
Battery Cell Volume (Cm^3)	9771	6632	4903	4009	3280	2852	2488	2187	1966
ESS Weight (Kg)	77682	55207	41221	35179	29720	26106	23499	21433	19518
ESS Volume (M^3)	312.320	312.320	274.720	158.930	158.930	158.930	158.930	158.930	75.748
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	56.999	38.660	28.880	24.832	21.414	19.242	17.687	16.466	15.381
Production Cost	277.768	192.076	142.236	121.083	102.508	90.417	81.727	74.873	68.628
Operations & Maintenance Cost	692.527	547.500	604.455	512.382	597.379	799.866	985.588	1266.314	1490.525
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ESS LIFE CYCLE COST	1027.294	778.236	775.571	658.297	721.301	909.525	1085.002	1357.653	1574.534
Solar Array Cost	1513.469	1512.891	1455.559	1500.834	1483.182	1479.556	1492.953	1514.150	1552.034
Thermal Control Cost	29.955	28.507	23.924	25.713	24.436	22.617	23.244	24.671	26.399
Power Conditioning Cost	2.961	2.961	2.961	2.961	2.961	2.961	2.961	2.961	2.961
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TOTAL LIFE CYCLE COST	2573.679	2322.595	2258.015	2187.805	2231.880	2414.659	2604.160	2899.435	3155.928

Exhibit 1d. Depth of Discharge (Capacity Variable)

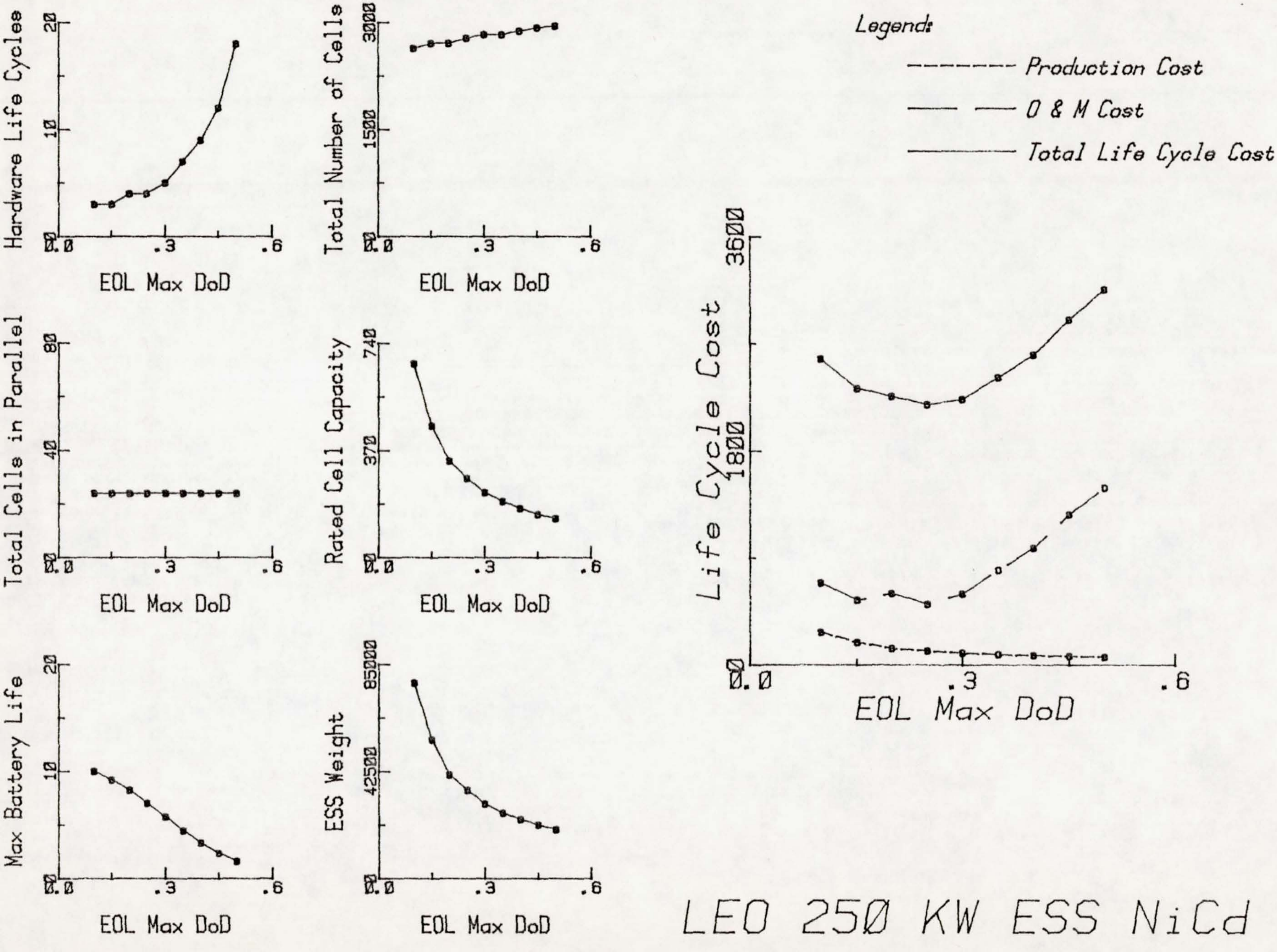

Exhibit 1d. Depth of Discharge (Capacity Variable) Continued

GEO 25KW ESS (NICd)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	1	1	1	1	1	1	1	1	1
Maximum Battery Life (Yr)	10.025	9.225	8.265	7.053	5.754	4.467	3.318	2.368	1.602
Rated Cell Capacity (AH)	235	160	120	95	85	70	60	55	50
Maximum Depth of Discharge	.100	.150	.200	.250	.300	.350	.400	.450	.500
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	19.877	20.298	20.296	20.081	21.554	20.700	20.264	20.875	21.049
Minimum Voltage (V)	1.321	1.295	1.283	1.271	1.261	1.249	1.236	1.224	1.211
Recharge Fraction	1.265	1.212	1.161	1.126	1.095	1.080	1.065	1.051	1.039
Charge Current (A)	1.307	1.279	1.226	1.176	1.227	1.162	1.122	1.141	1.137
Charge Voltage (V)	1.382	1.385	1.386	1.388	1.389	1.391	1.393	1.395	1.399
Watt-Hour Efficiency	.755	.772	.797	.813	.829	.832	.833	.835	.833
PHYSICAL CHARACTERISTICS									
Total Number of Cells	1176	1200	1212	1224	1236	1248	1260	1272	1284
Number of Parallel Batteries	12	12	12	12	12	12	12	12	12
Number of Modules per Battery	10	10	8	8	8	8	6	6	6
Battery Cell Weight (Kg)	9.318	6.363	4.786	3.801	3.407	2.816	2.422	2.224	2.027
Battery Cell Volume (Cm^3)	3423	2329	1746	1384	1235	1015	872	800	725
ESS Weight (Kg)	12127	8598	6633	5411	4952	4207	3699	3468	3230
ESS Volume (M^3)	67.147	67.147	37.874	37.874	37.874	37.874	22.491	22.491	22.491
LIFE CYCLE COSTS (1980M$)									
DDT&L Cost	17.735	14.372	12.572	11.466	11.053	10.386	9.933	9.726	9.515
Production Cost	181.743	130.128	101.546	83.829	77.183	66.423	59.100	55.773	52.351
Operations & Maintenance Cost	.500	.500	.500	.500	.500	.500	.500	.500	.500
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ESS LIFE CYCLE COST	199.978	145.000	114.618	95.795	88.736	77.309	69.533	65.999	62.366
Solar Array Cost	11.797	11.800	11.508	11.227	11.718	11.316	11.101	11.353	11.430
Thermal Control Cost	5.486	5.568	5.604	5.637	5.705	5.722	5.750	5.806	5.850
Power Conditioning Cost	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645
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TOTAL LIFE CYCLE COST	218.906	164.013	133.375	114.304	107.804	95.992	88.029	84.803	81.291

Exhibit 1e. Depth of Discharge (Capacity Variable)

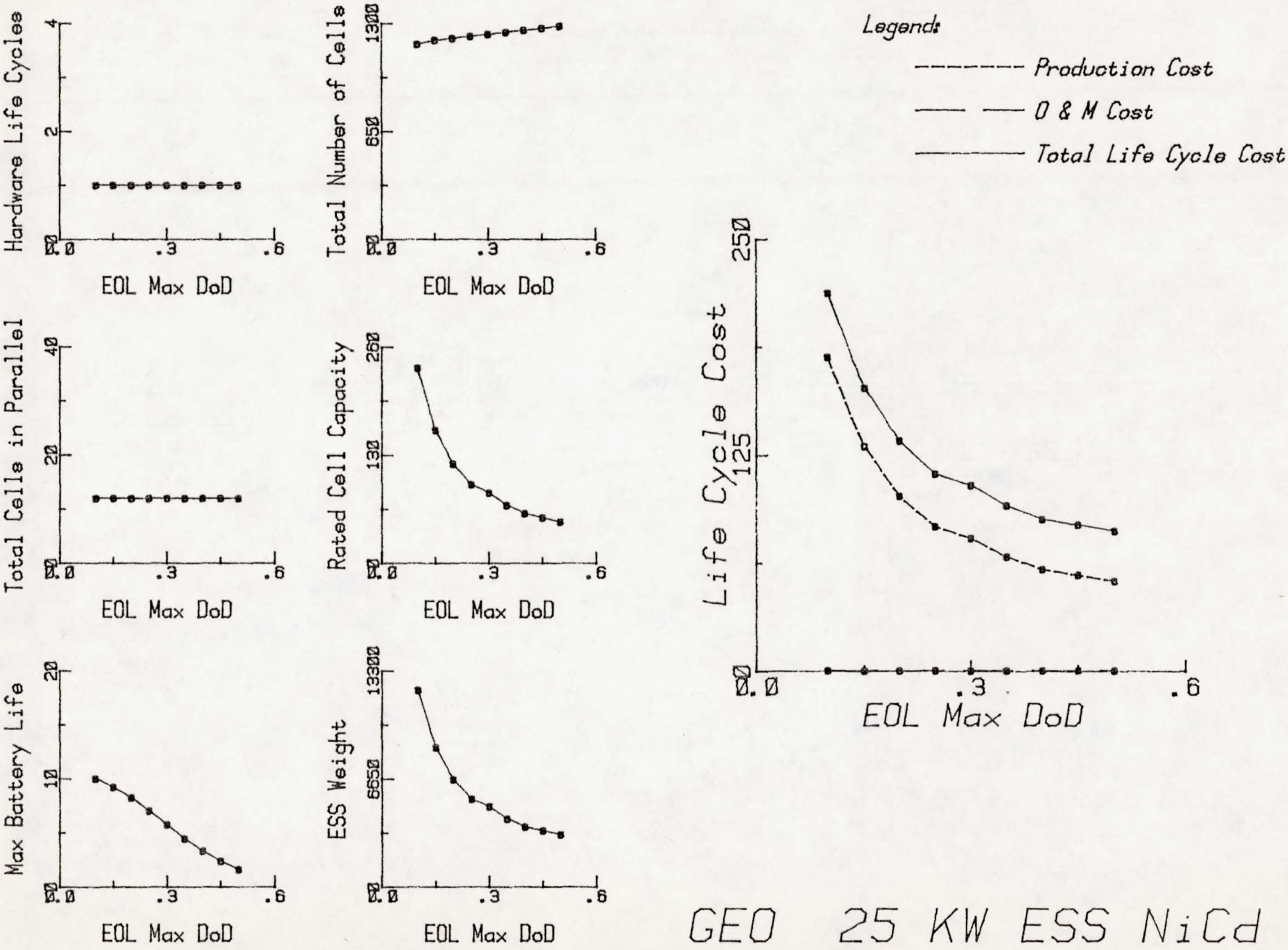

Exhibit 1e. Depth of Discharge (Capacity Variable) Continued

LEO 25KW ESS (NiCd)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	17	10	8	6	5	4	4	3	3
Maximum Battery Life (Yr)	1.700	2.800	3.900	5.000	6.100	7.200	8.300	9.400	10.500
Rated Cell Capacity (AH)	30	35	40	45	50	60	70	100	215
Maximum Depth of Discharge	.494	.426	.373	.330	.287	.244	.197	.141	.063
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	19.298	19.298	19.298	19.298	19.298	19.298	19.298	19.298	19.298
Minimum Voltage (V)	1.059	1.068	1.093	1.100	1.114	1.121	1.150	1.152	1.215
Recharge Fraction	1.005	1.005	1.021	1.036	1.048	1.070	1.086	1.140	1.256
Charge Current (A)	13.310	13.322	13.529	13.728	13.887	14.178	14.393	15.107	16.644
Charge Voltage (V)	1.705	1.693	1.662	1.661	1.651	1.650	1.616	1.628	1.580
Watt-Hour Efficiency	.619	.628	.644	.639	.644	.635	.655	.621	.612
PHYSICAL CHARACTERISTICS									
Total Number of Cells	1464	1452	1416	1416	1392	1380	1356	1344	1284
Number of Parallel Batteries	12	12	12	12	12	12	12	12	12
Number of Modules per Battery	6	6	6	6	6	6	8	8	10
Battery Cell Weight (Kg)	1.239	1.436	1.633	1.830	2.027	2.422	2.816	3.998	8.530
Battery Cell Volume (Cm^3)	434	507	578	654	725	872	1015	1455	3138
ESS Weight (Kg)	2440	2727	2962	3264	3509	4069	4583	6258	12223
ESS Volume (M^3)	15.681	22.491	22.491	22.491	22.491	22.491	37.874	37.874	67.147
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	9.468	9.749	9.958	10.256	10.479	11.015	11.500	13.114	19.086
Production Cost	13.691	14.582	15.287	16.238	16.989	18.751	20.369	25.742	45.493
Operations & Maintenance Cost	376.797	226.458	184.237	140.716	118.756	97.990	121.735	98.181	145.147
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ESS LIFE CYCLE COST	399.956	250.789	209.482	167.210	146.224	127.756	153.604	137.037	209.726
Solar Array Cost	237.226	234.521	229.259	231.851	229.643	231.797	227.528	236.282	240.272
Thermal Control Cost	7.113	7.071	6.939	7.063	7.059	7.224	7.071	7.553	7.886
Power Conditioning Cost	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645
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TOTAL LIFE CYCLE COST	645.940	494.026	447.325	407.769	384.571	368.422	389.848	382.517	459.529

Exhibit 2a. Cell Life (Capacity Variable)

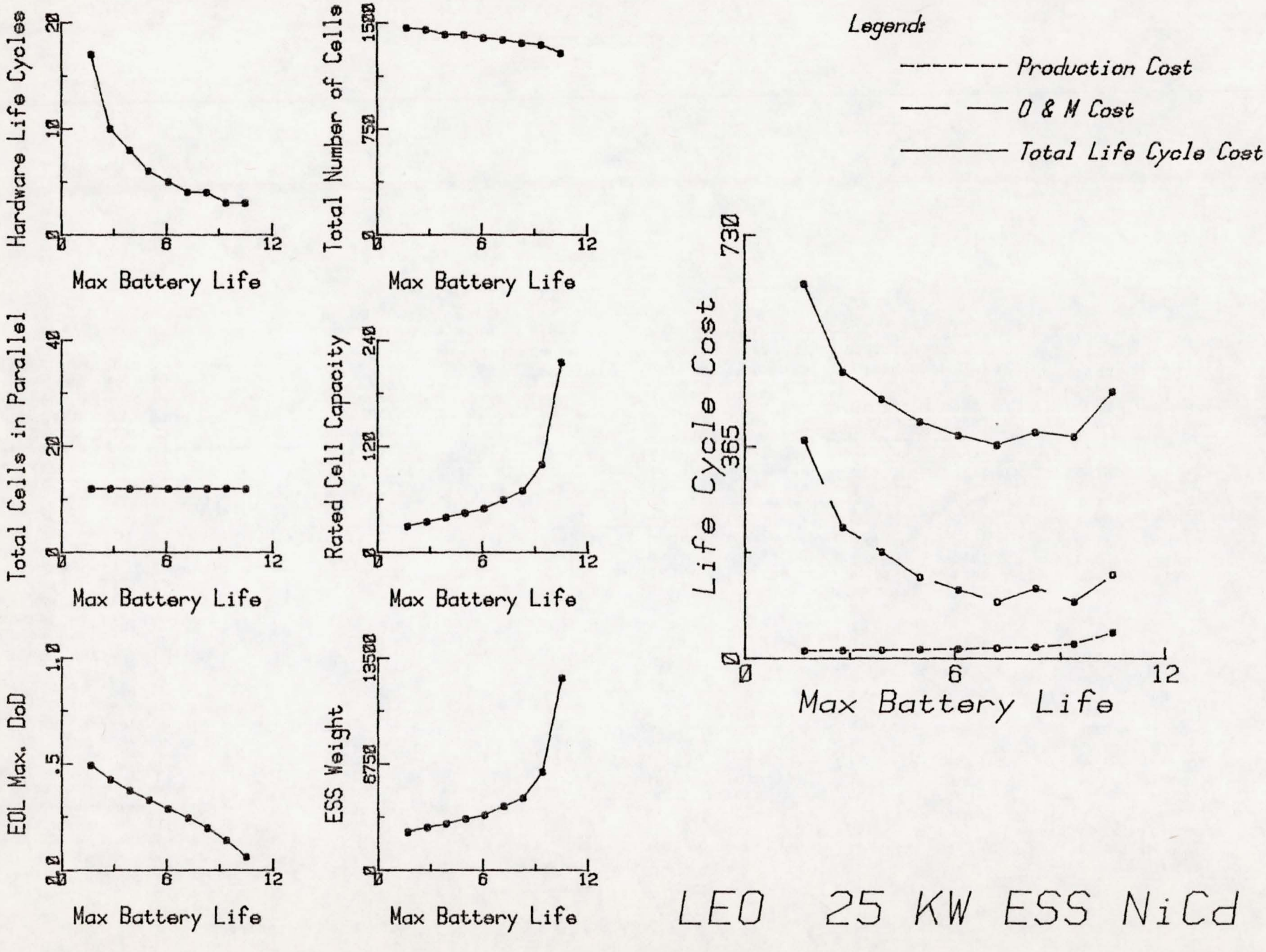

Exhibit 2a. Cell Life (Capacity Variable) Continued

LEO 50KW ESS (NiCd)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	17	10	8	6	5	4	4	3	3
Maximum Battery Life (Yr)	1.700	2.800	3.900	5.000	6.100	7.200	8.300	9.400	10.500
Rated Cell Capacity (AH)	55	65	75	85	95	115	135	195	425
Maximum Depth of Discharge	.494	.426	.373	.330	.287	.244	.197	.141	.063
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	38.594	38.594	38.594	38.594	38.594	38.594	38.594	38.594	38.594
Minimum Voltage (V)	1.054	1.064	1.090	1.096	1.110	1.119	1.148	1.152	1.215
Recharge Fraction	1.005	1.005	1.013	1.029	1.042	1.065	1.082	1.136	1.255
Charge Current (A)	26.619	26.619	26.833	27.260	27.612	28.222	28.683	30.101	33.249
Charge Voltage (V)	1.735	1.702	1.667	1.665	1.654	1.652	1.618	1.629	1.580
Watt-Hour Efficiency	.605	.623	.646	.640	.644	.636	.656	.622	.613
PHYSICAL CHARACTERISTICS									
Total Number of Cells	1476	1464	1428	1416	1392	1392	1356	1344	1284
Number of Parallel Batteries	12	12	12	12	12	12	12	12	12
Number of Modules per Battery	8	8	8	8	8	8	8	10	12
Battery Cell Weight (Kg)	2.224	2.619	3.013	3.407	3.801	4.589	5.377	7.742	16.806
Battery Cell Volume (Cm^3)	800	944	1093	1235	1384	1675	1966	2852	6212
ESS Weight (Kg)	4216	4789	5270	5834	6331	7515	8461	11844	23792
ESS Volume (M^3)	28.107	37.874	37.874	37.874	37.874	37.874	37.874	67.147	79.465
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	10.247	10.771	11.194	11.698	12.136	13.223	14.102	17.322	30.313
Production Cost	19.189	21.018	22.533	24.328	25.907	29.740	32.827	44.030	86.109
Operations & Maintenance Cost	519.340	316.072	259.885	199.863	169.988	142.940	150.311	142.231	227.047
ESS LIFE CYCLE COST	548.776	347.861	293.612	235.889	208.031	185.903	197.240	203.583	343.469
Solar Array Cost	422.520	413.179	400.923	402.906	399.419	406.194	396.175	411.213	418.924
Thermal Control Cost	9.327	9.033	8.626	8.853	8.864	9.236	8.907	9.860	10.557
Power Conditioning Cost	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645
TOTAL LIFE CYCLE COST	982.268	771.718	704.806	649.293	617.959	602.978	603.967	626.301	774.595

Exhibit 2b. Cell Life (Capacity Variable)

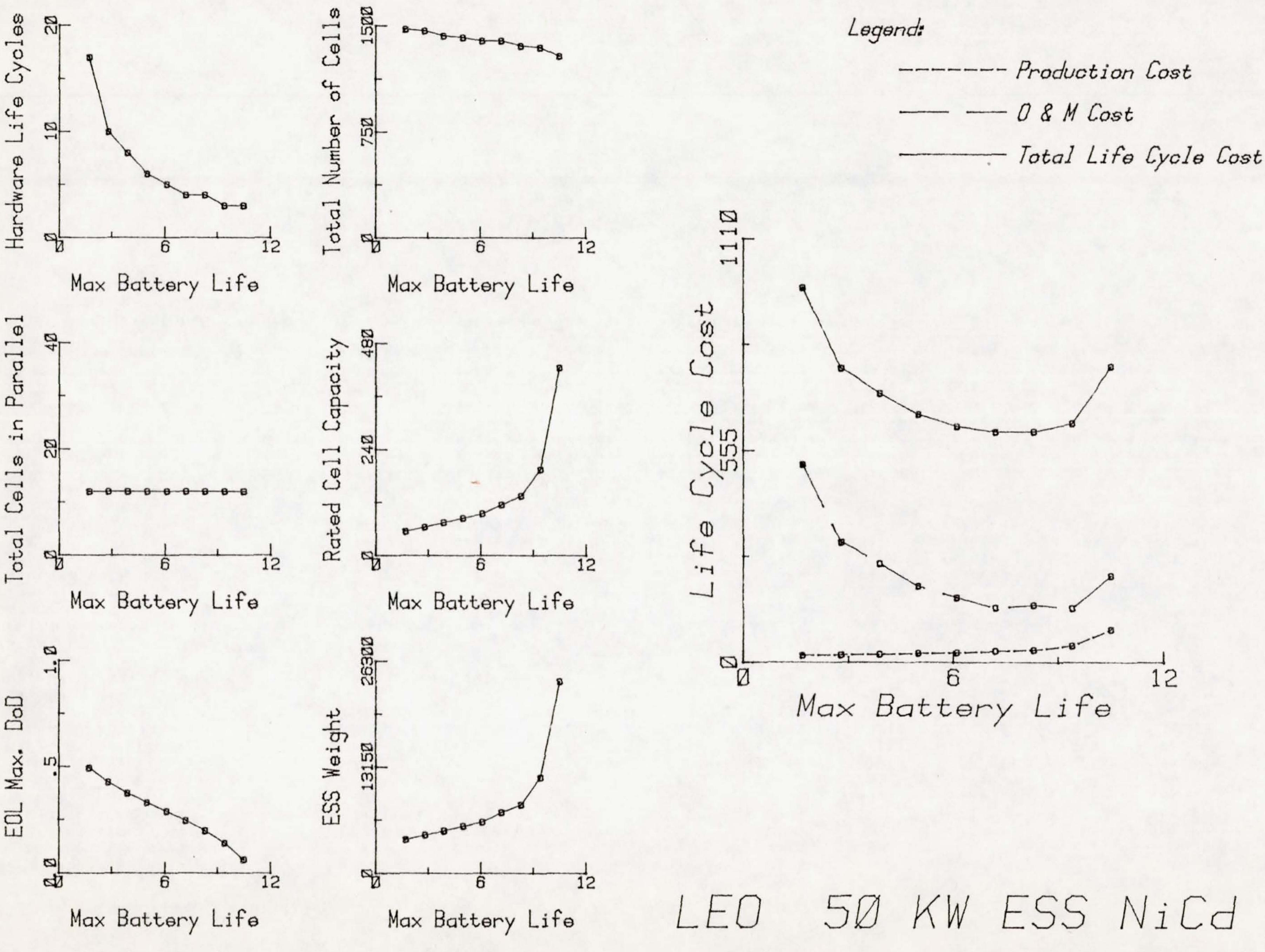

Exhibit 2b. Cell Life (Capacity Variable) Continued

LEO 100KW ESS (NiCd)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	17	10	8	6	5	4	4	3	3
Maximum Battery Life (Yr)	1.700	2.800	3.900	5.000	6.100	7.200	8.300	9.400	10.500
Rated Cell Capacity (AH)	110	130	145	165	190	225	270	385	850
Maximum Depth of Discharge	.494	.426	.373	.330	.287	.244	.197	.141	.063
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	77.188	77.188	77.188	77.188	77.188	77.188	77.188	77.188	77.188
Minimum Voltage (V)	1.054	1.064	1.088	1.095	1.110	1.117	1.148	1.151	1.215
Recharge Fraction	1.005	1.005	1.009	1.025	1.042	1.062	1.082	1.134	1.255
Charge Current (A)	53.238	53.238	53.466	54.303	55.225	56.301	57.367	60.085	66.498
Charge Voltage (V)	1.735	1.702	1.669	1.667	1.654	1.654	1.618	1.630	1.580
Watt-Hour Efficiency	.605	.623	.646	.641	.644	.636	.656	.623	.613
PHYSICAL CHARACTERISTICS									
Total Number of Cells	1476	1464	1428	1416	1392	1392	1356	1344	1284
Number of Parallel Batteries	12	12	12	12	12	12	12	12	12
Number of Modules per Battery	8	8	12	12	12	12	12	12	18
Battery Cell Weight (Kg)	4.392	5.180	5.771	6.560	7.545	8.924	10.698	15.230	33.555
Battery Cell Volume (Cm^3)	1604	1895	2108	2409	2773	3280	3946	5625	12423
ESS Weight (Kg)	8005	9152	9927	11060	12355	14429	16619	23044	47341
ESS Volume (M^3)	37.874	37.874	79.465	79.465	79.465	79.465	79.465	79.465	116.390
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	12.446	13.470	14.148	15.161	16.354	18.305	20.500	27.235	59.752
Production Cost	31.102	34.867	37.393	41.122	45.442	52.428	60.005	82.674	178.198
Operations & Maintenance Cost	656.808	407.508	414.788	321.861	278.978	235.692	254.134	220.075	429.822
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ESS LIFE CYCLE COST	700.356	455.845	466.329	378.144	340.774	306.425	334.639	329.984	667.772
Solar Array Cost	737.189	720.868	698.251	701.375	696.893	707.655	691.250	716.456	730.891
Thermal Control Cost	13.454	12.865	11.987	12.425	12.528	13.217	12.613	14.468	15.913
Power Conditioning Cost	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645
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TOTAL LIFE CYCLE COST	1452.644	1191.223	1178.212	1093.589	1051.840	1028.942	1040.147	1062.553	1416.221

Exhibit 2c. Cell Life (Capacity Variable)

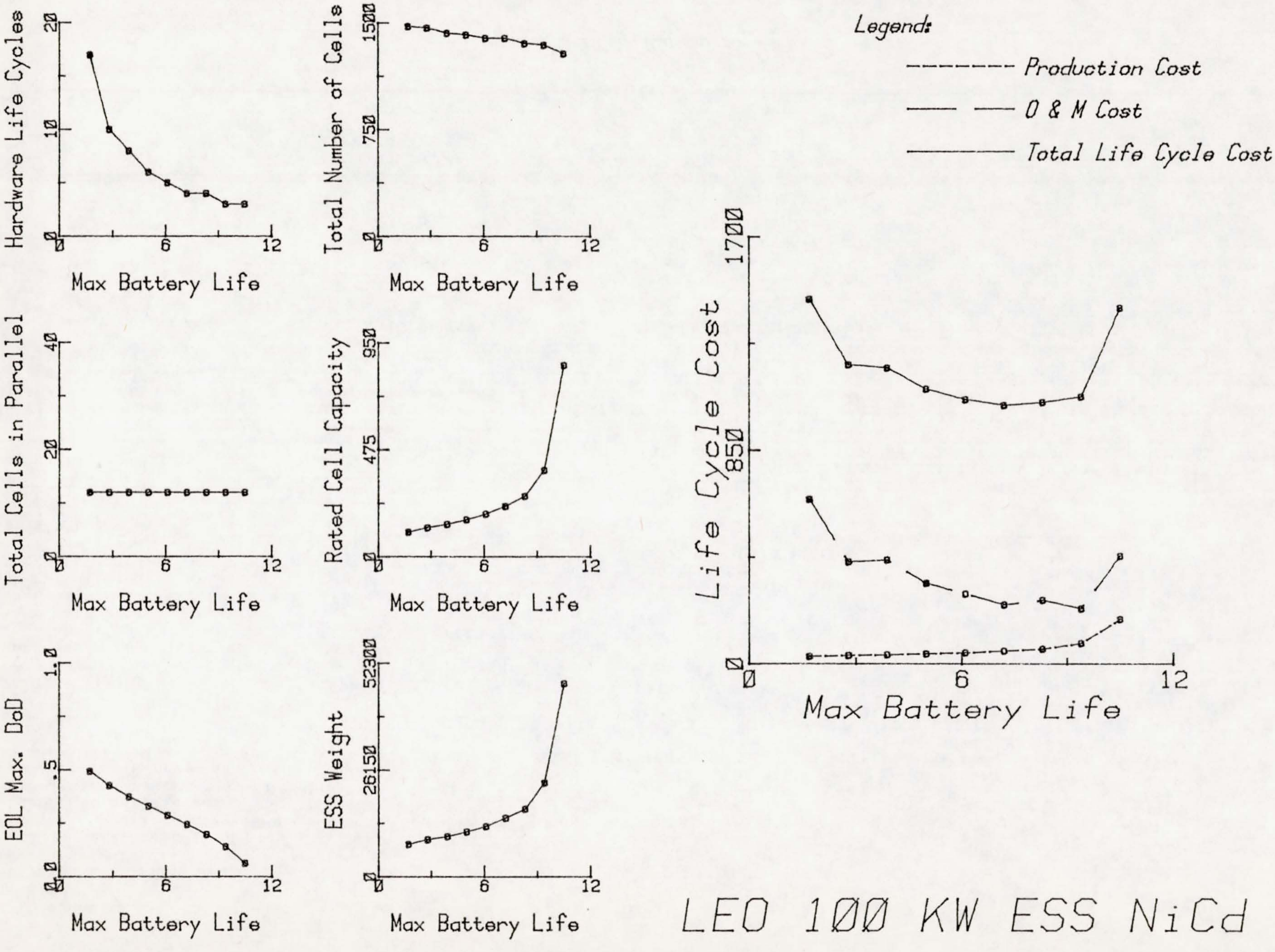

Exhibit 2c. Cell Life (Capacity Variable) Continued

LEO 250KW ESS (NICd)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	17	10	8	6	5	4	4	3	3
Maximum Battery Life (Yr)	1.700	2.800	3.900	5.000	6.100	7.200	8.300	9.400	10.500
Rated Cell Capacity (AH)	140	160	180	205	235	280	340	480	1065
Maximum Depth of Discharge	.494	.426	.373	.330	.287	.244	.197	.141	.063
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	96.485	96.485	96.485	96.485	96.485	96.485	96.485	96.485	96.485
Minimum Voltage (V)	1.055	1.063	1.088	1.095	1.110	1.117	1.149	1.151	1.215
Recharge Fraction	1.005	1.005	1.008	1.024	1.041	1.062	1.083	1.133	1.255
Charge Current (A)	66.546	66.546	66.778	67.825	68.945	70.342	71.760	75.079	83.142
Charge Voltage (V)	1.728	1.703	1.670	1.667	1.655	1.654	1.618	1.630	1.580
Watt-Hour Efficiency	.608	.621	.646	.641	.644	.636	.656	.623	.613
PHYSICAL CHARACTERISTICS									
Total Number of Cells	2952	2923	2856	2832	2808	2784	2712	2688	2568
Number of Parallel Batteries	24	24	24	24	24	24	24	24	24
Number of Modules per Battery	12	12	12	12	12	12	12	14	26
Battery Cell Weight (Kg)	5.574	6.363	7.151	8.136	9.318	11.092	13.456	18.974	42.029
Battery Cell Volume (Cm^3)	2044	2329	2630	2995	3423	4088	4960	7004	15561
ESS Weight (Kg)	20379	22646	24454	27287	30628	35712	41620	57397	118990
ESS Volume (M^3)	158.930	158.930	158.930	158.930	158.930	158.930	158.930	183.560	331.260
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	15.851	17.180	18.277	19.953	22.000	25.197	29.200	40.421	97.929
Production Cost	71.393	78.889	84.956	94.370	105.636	122.967	143.748	200.382	450.143
Operations & Maintenance Cost	1762.570	1078.427	890.546	695.170	607.599	517.100	567.927	530.594	1147.983
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ESS LIFE CYCLE COST	1849.814	1174.496	993.779	809.493	735.235	665.264	740.875	771.397	1696.055
Solar Array Cost	1533.545	1505.843	1456.761	1463.283	1463.523	1476.545	1443.283	1494.967	1525.638
Thermal Control Cost	25.519	24.445	22.128	23.223	23.611	25.217	23.776	28.345	31.993
Power Conditioning Cost	2.961	2.961	2.961	2.961	2.961	2.961	2.961	2.961	2.961
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TOTAL LIFE CYCLE COST	3411.839	2707.745	2475.629	2298.960	2225.330	2169.987	2210.895	2297.670	3256.647

Exhibit 2d. Cell Life (Capacity Variable)

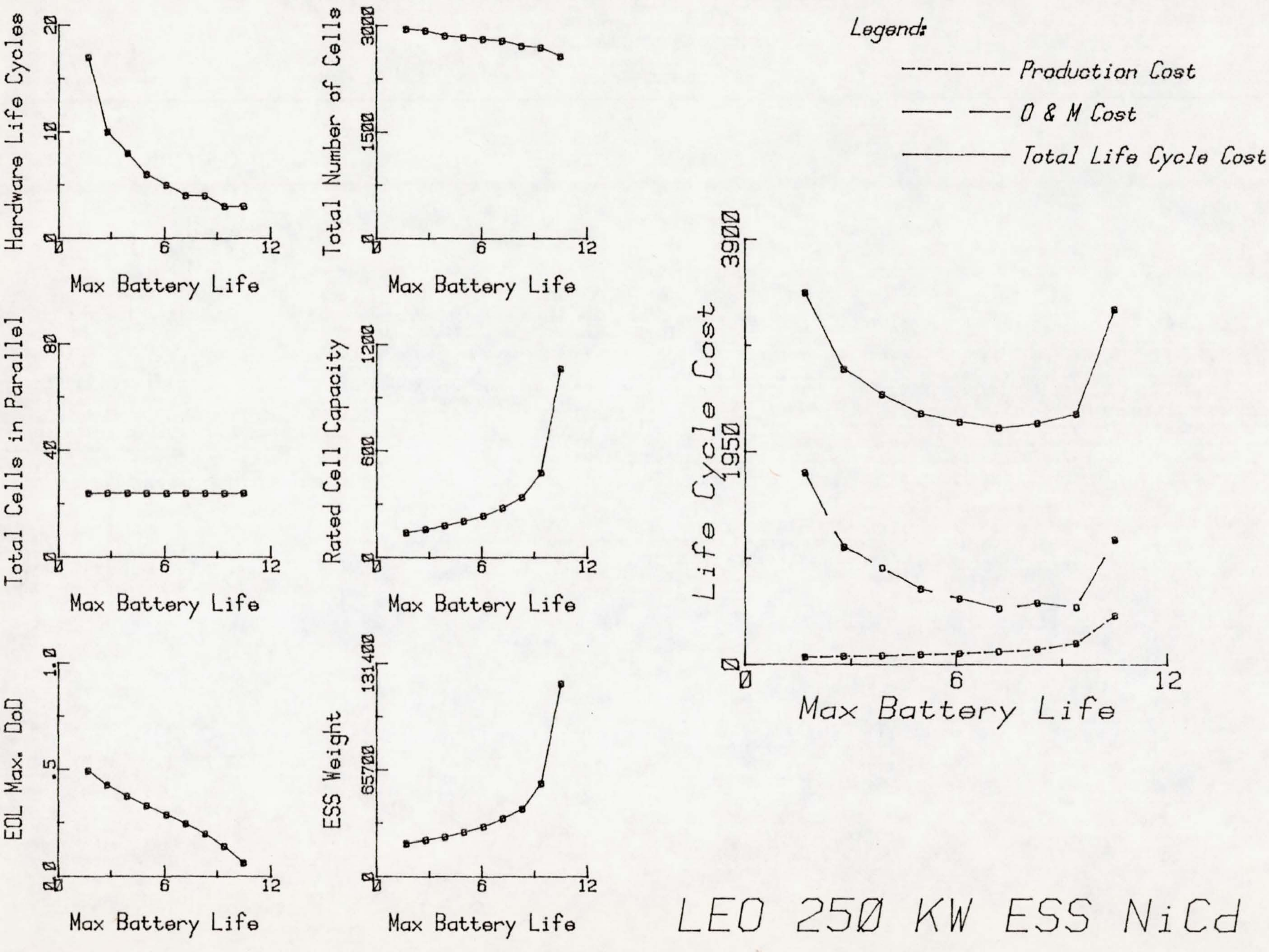

Exhibit 2d. Cell Life (Capacity Variable) Continued

GEO 25KW ESS (NICd)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	1	1	1	1	1	1	1	1	1
Maximum Battery Life (Yr)	1.700	2.800	3.900	5.000	6.100	7.200	8.300	9.400	10.500
Rated Cell Capacity (AH)	50	55	65	70	80	95	120	165	365
Maximum Depth of Discharge	.494	.426	.373	.330	.287	.244	.197	.141	.063
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	19.297	19.297	19.297	19.297	19.297	19.297	19.297	19.297	19.297
Minimum Voltage (V)	1.218	1.232	1.246	1.254	1.264	1.273	1.285	1.301	1.348
Recharge Fraction	1.049	1.061	1.080	1.087	1.102	1.133	1.169	1.224	1.306
Charge Current (A)	1.053	1.064	1.083	1.091	1.106	1.137	1.173	1.228	1.310
Charge Voltage (V)	1.398	1.394	1.391	1.390	1.389	1.387	1.386	1.384	1.381
Watt-Hour Efficiency	.830	.833	.830	.830	.826	.810	.793	.768	.748
PHYSICAL CHARACTERISTICS									
Total Number of Cells	1272	1260	1248	1236	1224	1224	1212	1200	1152
Number of Parallel Batteries	12	12	12	12	12	12	12	12	12
Number of Modules per Battery	6	6	8	8	8	8	8	10	10
Battery Cell Weight (Kg)	2.027	2.224	2.619	2.816	3.210	3.801	4.786	6.560	14.442
Battery Cell Volume (Cm^3)	725	800	944	1015	1164	1384	1746	2409	5324
ESS Weight (Kg)	3193	3429	3936	4161	4637	5406	6626	8842	18163
ESS Volume (M^3)	22.491	22.491	37.874	37.874	37.874	37.874	37.874	67.147	67.147
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	9.476	9.685	10.141	10.338	10.764	11.465	12.569	14.601	23.958
Production Cost	51.810	55.204	62.600	65.749	72.622	83.759	101.449	133.689	270.889
Operations & Maintenance Cost	.500	.500	.500	.500	.500	.500	.500	.500	.500
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ESS LIFE CYCLE COST	61.786	65.389	73.241	76.587	83.886	95.724	114.518	148.790	295.347
Solar Array Cost	10.660	10.644	10.697	10.669	10.693	10.926	11.106	11.416	11.614
Thermal Control Cost	5.771	5.736	5.693	5.668	5.639	5.615	5.581	5.536	5.402
Power Conditioning Cost	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645
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TOTAL LIFE CYCLE COST	79.862	83.414	91.276	94.569	101.863	113.910	132.850	167.387	314.008

Exhibit 2e. Cell Life (Capacity Variable)

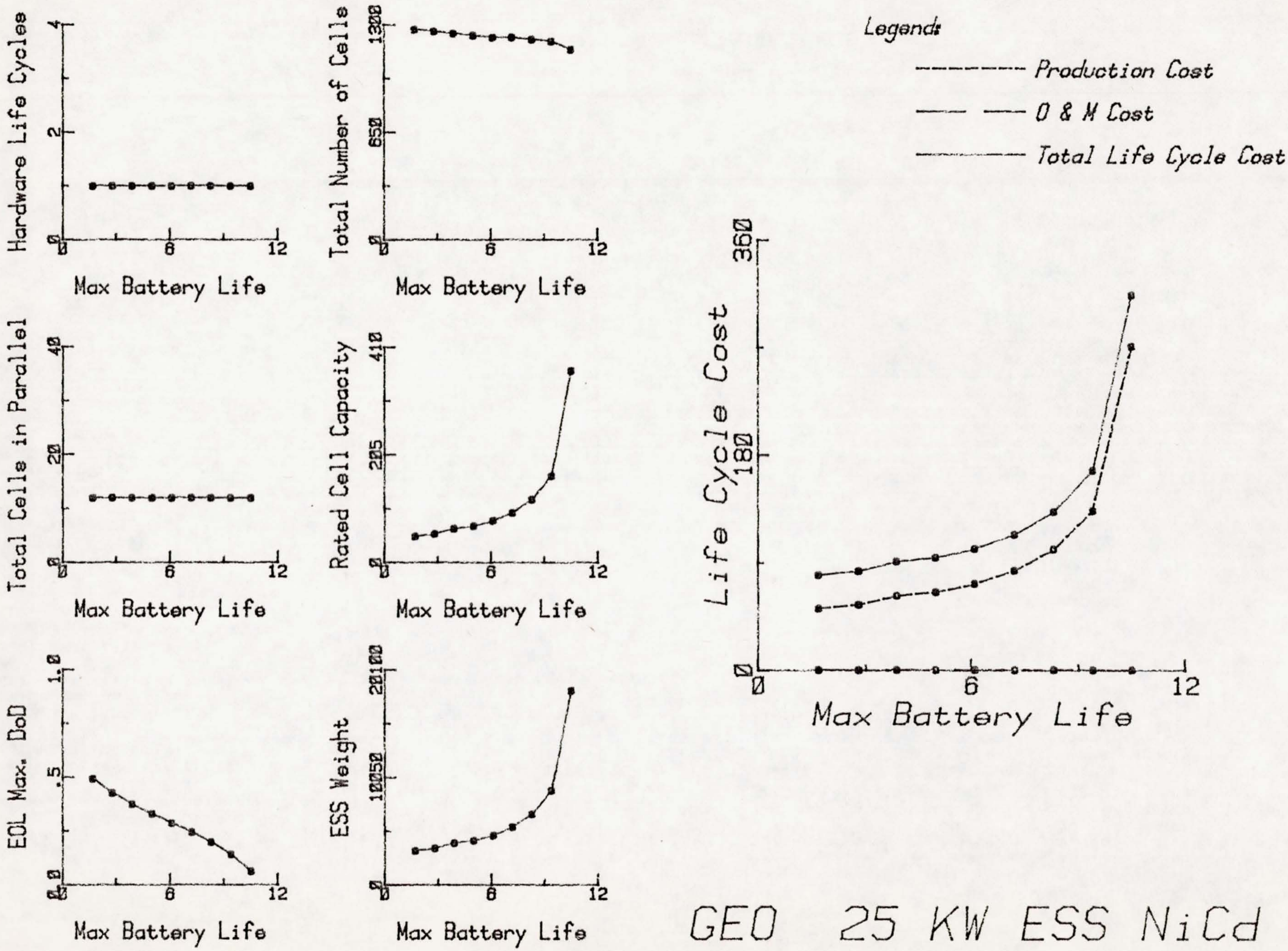

Exhibit 2e. Cell Life (Capacity Variable) Continued

LEO 25KW ESS (NiCd)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	3	3	4	4	5	7	9	12	18
Maximum Battery Life (Yr)	10.025	9.225	8.265	7.053	5.754	4.467	3.318	2.368	1.602
Rated Cell Capacity (AH)	50	50	50	50	50	50	50	50	50
Maximum Depth of Discharge	.100	.150	.200	.250	.300	.350	.400	.450	.500
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	7.018	10.526	14.473	17.813	21.051	23.157	25.729	28.946	33.080
Minimum Voltage (V)	1.182	1.144	1.147	1.112	1.099	1.098	1.082	1.066	1.057
Recharge Fraction	1.192	1.126	1.081	1.058	1.038	1.026	1.013	1.005	1.005
Charge Current (A)	5.743	8.136	10.745	12.937	15.002	16.319	17.896	19.964	22.816
Charge Voltage (V)	1.605	1.636	1.619	1.660	1.667	1.659	1.675	1.696	1.714
Watt-Hour Efficiency	.618	.622	.655	.634	.635	.645	.638	.626	.614
PHYSICAL CHARACTERISTICS									
Total Number of Cells	3597	2486	1808	1508	1298	1180	1080	968	854
Number of Parallel Batteries	33	22	16	13	11	10	9	8	7
Number of Modules per Battery	8	8	8	8	6	6	6	8	8
Battery Cell Weight (Kg)	2.027	2.027	2.027	2.027	2.027	2.027	2.027	2.027	2.027
Battery Cell Volume (Cm^3)	725	725	725	725	725	725	725	725	725
ESS Weight (Kg)	9506	6725	4532	4116	3566	2992	3084	2498	2227
ESS Volume (M^3)	74.020	45.906	30.604	29.608	22.491	20.580	20.580	15.302	14.804
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	17.093	13.866	11.770	10.905	10.240	9.811	9.564	9.142	8.770
Production Cost	37.458	27.664	20.645	18.688	16.765	15.138	14.965	13.345	12.365
Operations & Maintenance Cost	221.056	150.078	148.623	122.975	109.944	142.696	169.662	244.383	327.342
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ESS LIFE CYCLE COST	275.607	191.608	181.038	152.568	136.949	167.645	194.191	266.870	348.477
Solar Array Cost	236.792	236.384	227.024	232.368	232.869	229.843	232.336	234.612	238.153
Thermal Control Cost	7.677	7.522	7.054	7.214	7.129	6.960	6.993	7.066	7.151
Power Conditioning Cost	3.879	2.750	2.100	1.761	1.528	1.409	1.289	1.166	1.042
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TOTAL LIFE CYCLE COST	523.955	438.264	417.216	393.911	378.475	405.857	434.809	509.714	594.823

Exhibit 3a. Depth of Discharge (Capacity Fixed)

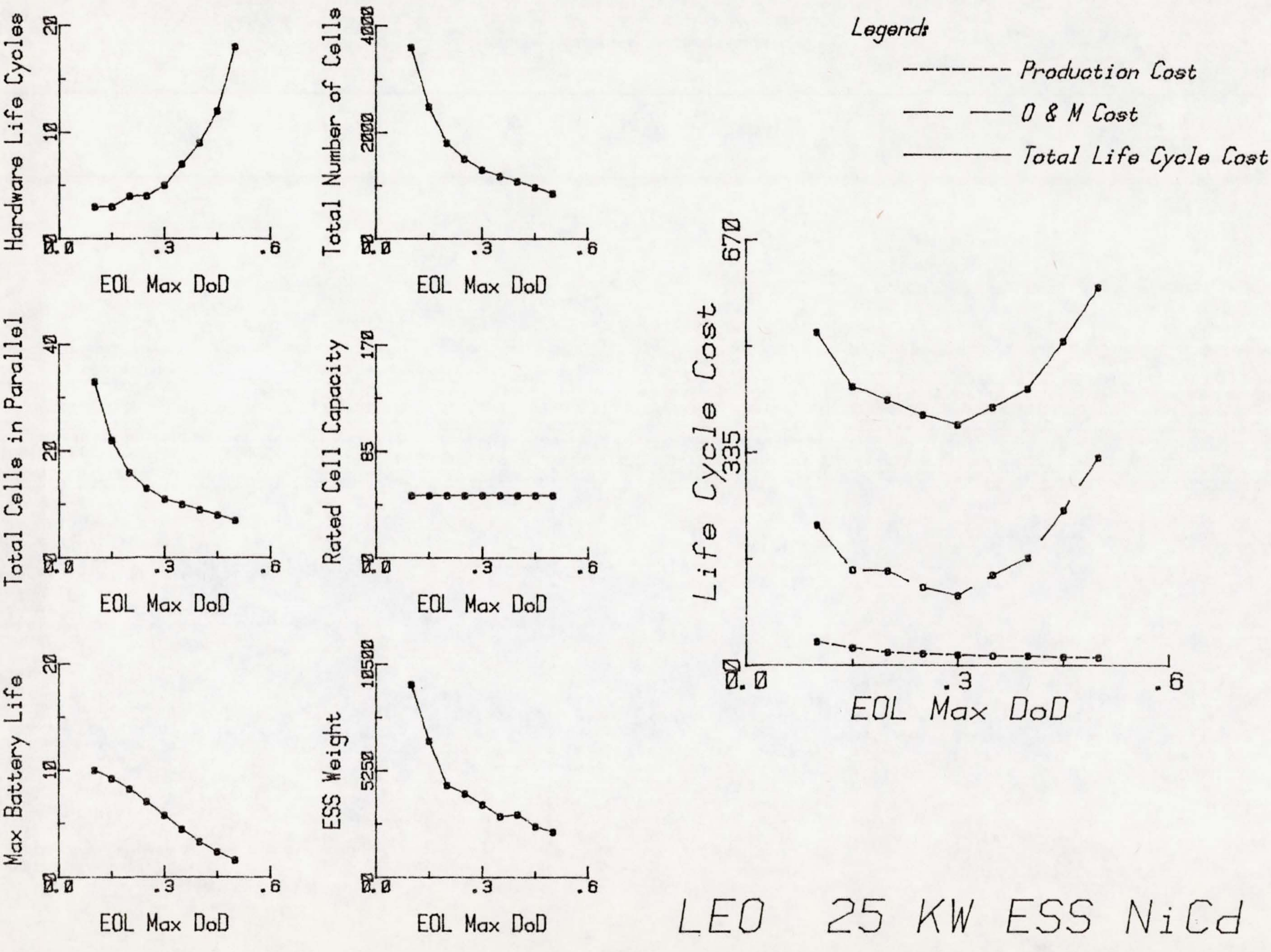

Exhibit 3a. Depth of Discharge (Capacity Fixed) Continued

LEO 50KW ESS (NiCd)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	3	3	4	4	5	7	9	12	18
Maximum Battery Life (Yr)	10.025	9.225	8.265	7.053	5.754	4.467	3.318	2.368	1.602
Rated Cell Capacity (AH)	50	50	50	50	50	50	50	50	50
Maximum Depth of Discharge	.100	.150	.200	.250	.300	.350	.400	.450	.500
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	7.126	10.526	14.473	17.813	21.051	24.375	27.243	30.875	35.626
Minimum Voltage (V)	1.181	1.144	1.147	1.112	1.099	1.096	1.079	1.062	1.052
Recharge Fraction	1.189	1.126	1.081	1.058	1.038	1.019	1.007	1.005	1.005
Charge Current (A)	5.818	8.136	10.745	12.937	15.002	17.058	18.827	21.295	24.572
Charge Voltage (V)	1.605	1.636	1.619	1.660	1.667	1.662	1.680	1.703	1.742
Watt-Hour Efficiency	.619	.622	.655	.634	.635	.647	.638	.621	.601
PHYSICAL CHARACTERISTICS									
Total Number of Cells	7150	4972	3616	3016	2596	2242	2040	1830	1599
Number of Parallel Batteries	65	44	32	26	22	19	17	15	13
Number of Modules per Battery	8	8	8	8	8	8	8	8	8
Battery Cell Weight (Kg)	2.027	2.027	2.027	2.027	2.027	2.027	2.027	2.027	2.027
Battery Cell Volume (Cm^3)	725	725	725	725	725	725	725	725	725
ESS Weight (Kg)	19560	13449	9062	8231	7134	6342	5593	5014	4511
ESS Volume (M^3)	137.720	91.811	61.208	59.216	45.906	44.412	42.160	30.604	29.608
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	25.680	19.764	15.977	14.383	13.206	12.222	11.621	11.016	10.363
Production Cost	71.146	50.659	36.661	32.780	28.976	26.050	23.758	21.794	19.911
Operations & Maintenance Cost	431.221	295.608	290.673	238.986	256.839	314.940	367.010	437.898	579.386
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ESS LIFE CYCLE COST	528.047	366.031	343.311	286.149	299.021	353.212	402.389	470.708	609.660
Solar Array Cost	415.493	412.430	396.099	405.418	406.292	399.447	404.135	413.549	423.803
Thermal Control Cost	10.166	9.844	8.908	9.226	9.057	8.650	8.728	9.031	9.388
Power Conditioning Cost	6.893	4.951	3.779	3.169	2.750	2.429	2.210	1.988	1.761
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TOTAL LIFE CYCLE COST	960.599	793.256	752.097	703.962	717.120	763.738	817.462	895.276	1044.612

Exhibit 3b. Depth of Discharge (Capacity Fixed)

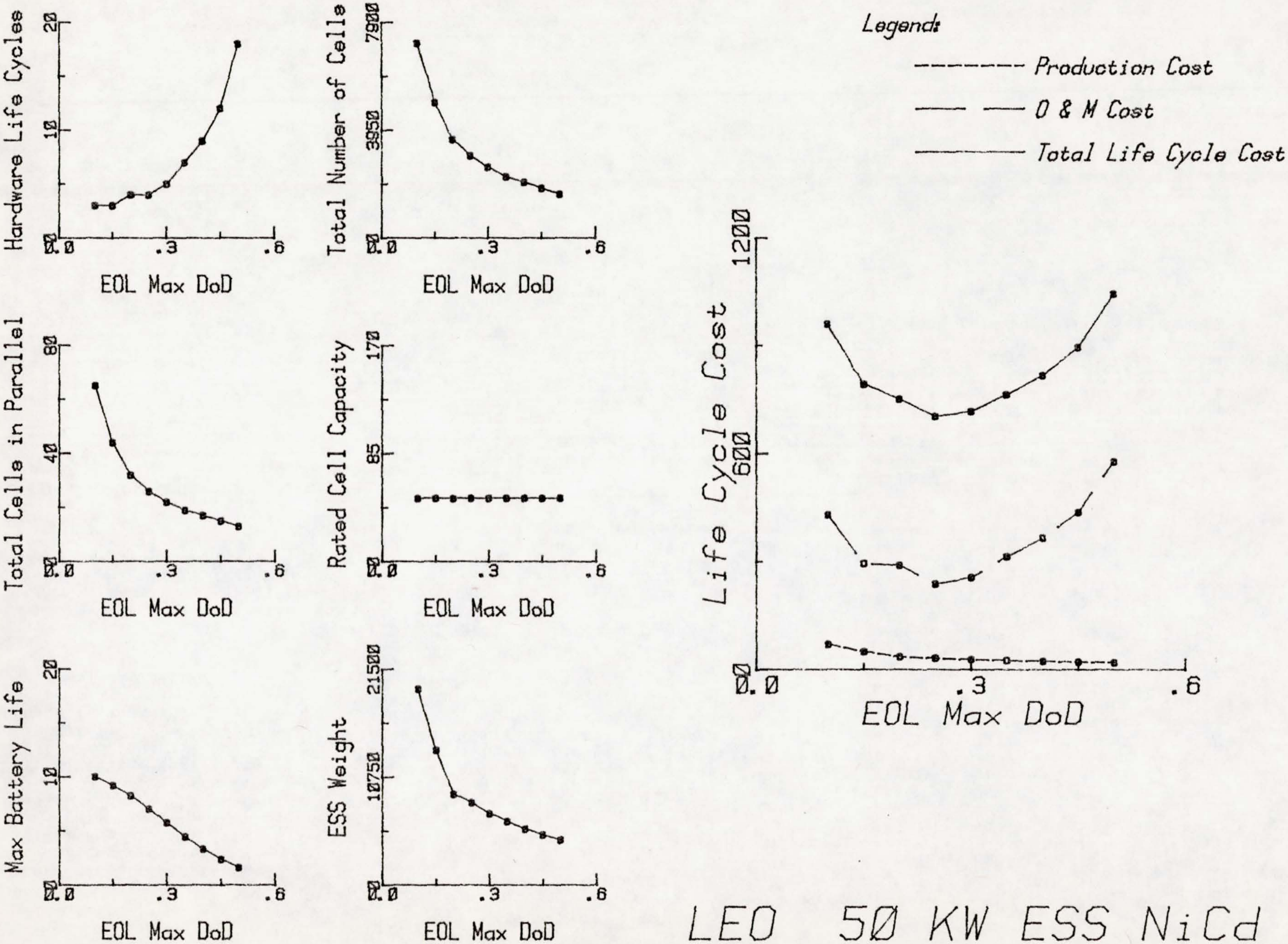

Exhibit 3b. Depth of Discharge (Capacity Fixed) Continued

LEO 100KW ESS (NiCd)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	3	3	4	4	5	7	9	12	18
Maximum Battery Life (Yr)	10.025	9.225	8.265	7.053	5.754	4.467	3.318	2.368	1.602
Rated Cell Capacity (AH)	50	50	50	50	50	50	50	50	50
Maximum Depth of Discharge	.100	.150	.200	.250	.300	.350	.400	.450	.500
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	7.181	10.647	14.473	17.813	21.542	25.035	28.069	31.940	35.626
Minimum Voltage (V)	1.181	1.144	1.147	1.112	1.098	1.094	1.077	1.060	1.052
Recharge Fraction	1.188	1.124	1.081	1.058	1.035	1.015	1.005	1.005	1.005
Charge Current (A)	5.856	8.215	10.745	12.937	15.310	17.453	19.359	22.029	24.572
Charge Voltage (V)	1.606	1.636	1.619	1.660	1.669	1.664	1.682	1.708	1.742
Watt-Hour Efficiency	.620	.622	.655	.634	.636	.648	.637	.618	.601
PHYSICAL CHARACTERISTICS									
Total Number of Cells	14190	9831	7232	6032	5074	4366	3960	3538	3198
Number of Parallel Batteries	129	87	64	52	43	37	33	29	26
Number of Modules per Battery	8	8	8	8	8	8	8	8	8
Battery Cell Weight (Kg)	2.027	2.027	2.027	2.027	2.027	2.027	2.027	2.027	2.027
Battery Cell Volume (Cm^3)	725	725	725	725	725	725	725	725	725
ESS Weight (Kg)	36950	24722	18123	16317	14255	11980	10803	10011	9022
ESS Volume (M^3)	260.130	168.320	122.420	107.110	91.811	76.509	74.020	61.208	59.216
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	42.312	31.029	24.309	21.283	18.817	16.938	15.867	14.784	13.883
Production Cost	132.389	91.533	68.560	60.542	52.829	45.554	41.650	38.494	35.217
Operations & Maintenance Cost	850.894	579.235	574.307	471.100	493.416	599.935	696.054	825.966	1120.599
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ESS LIFE CYCLE COST	1025.595	701.797	667.176	552.925	565.062	662.427	753.571	879.244	1169.699
Solar Array Cost	724.376	718.745	691.085	707.327	707.901	695.411	704.948	722.948	739.420
Thermal Control Cost	15.103	14.447	12.613	13.250	12.860	12.021	12.246	12.937	13.577
Power Conditioning Cost	12.326	8.826	6.803	5.704	4.855	4.274	3.879	3.477	3.169
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TOTAL LIFE CYCLE COST	1777.400	1443.815	1377.677	1279.206	1290.678	1374.133	1474.644	1618.606	1925.865

Exhibit 3c. Depth of Discharge (Capacity Fixed)

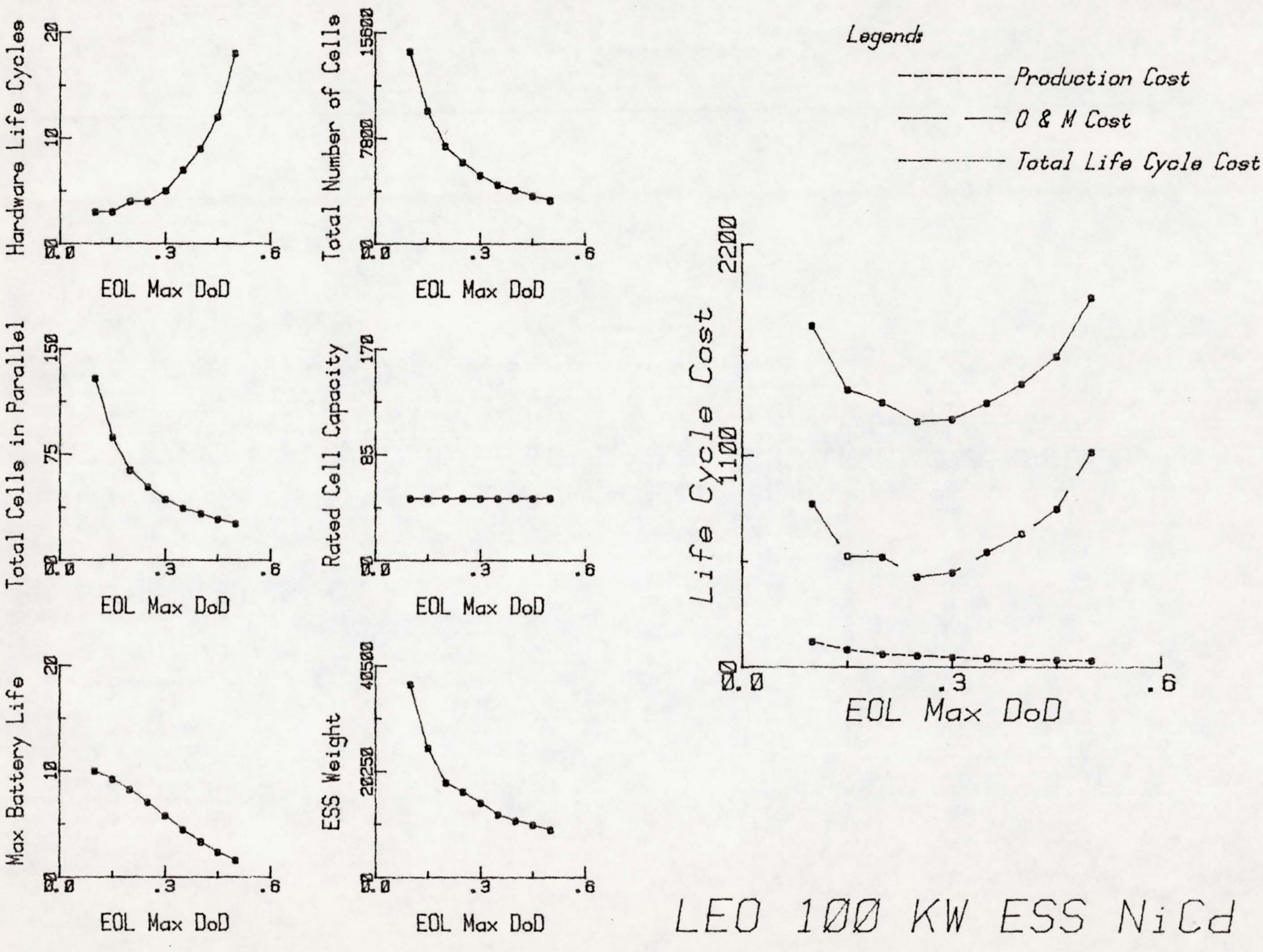

Exhibit 3c. Depth of Discharge (Capacity Fixed) Continued

LEO 250KW ESS (NiCd)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	3	3	4	4	5	7	9	12	18
Maximum Battery Life (Yr)	10.025	9.225	8.265	7.053	5.754	4.467	3.318	2.368	1.602
Rated Cell Capacity (AH)	50	50	50	50	50	50	50	50	50
Maximum Depth of Discharge	.100	.150	.200	.250	.300	.350	.400	.450	.500
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	7.214	10.721	14.564	17.813	21.441	25.171	28.588	32.162	35.626
Minimum Voltage (V)	1.181	1.144	1.147	1.112	1.098	1.094	1.076	1.060	1.052
Recharge Fraction	1.187	1.123	1.081	1.058	1.036	1.015	1.005	1.005	1.005
Charge Current (A)	5.878	8.263	10.805	12.937	15.247	17.537	19.718	22.183	24.572
Charge Voltage (V)	1.606	1.636	1.620	1.660	1.669	1.664	1.684	1.709	1.742
Watt-Hour Efficiency	.620	.623	.655	.634	.635	.648	.636	.618	.601
PHYSICAL CHARACTERISTICS									
Total Number of Cells	35310	24408	17967	15080	12744	10856	9720	8784	7995
Number of Parallel Batteries	321	216	159	130	108	92	81	72	65
Number of Modules per Battery	8	8	8	8	8	8	8	8	10
Battery Cell Weight (Kg)	2.027	2.027	2.027	2.027	2.027	2.027	2.027	2.027	2.027
Battery Cell Volume (Cm^3)	725	725	725	725	725	725	725	725	725
ESS Weight (Kg)	89120	60714	45305	39703	33468	28854	26943	22843	23439
ESS Volume (M^3)	627.380	413.150	306.040	260.130	214.230	183.620	168.320	137.720	165.370
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	63.595	45.424	34.739	29.984	26.081	22.928	21.060	19.429	18.263
Production Cost	315.320	218.090	163.434	141.624	120.421	104.141	96.150	84.306	82.895
Operations & Maintenance Cost	2106.989	1429.094	1414.374	1165.618	1223.727	1469.915	1679.923	2010.772	3210.828
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ESS LIFE CYCLE COST	2485.904	1692.608	1612.547	1337.226	1370.229	1596.984	1797.133	2114.507	3311.986
Solar Array Cost	1510.781	1498.958	1441.803	1476.305	1477.811	1450.886	1472.744	1509.589	1543.236
Thermal Control Cost	29.901	28.240	23.705	25.322	24.375	22.217	22.906	24.584	26.140
Power Conditioning Cost	26.702	19.083	14.717	12.407	10.602	9.254	8.307	7.517	6.893
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TOTAL LIFE CYCLE COST	4053.288	3238.889	3092.772	2851.260	2883.017	3079.341	3301.090	3656.197	4888.255

Exhibit 3d. Depth of Discharge (Capacity Fixed)

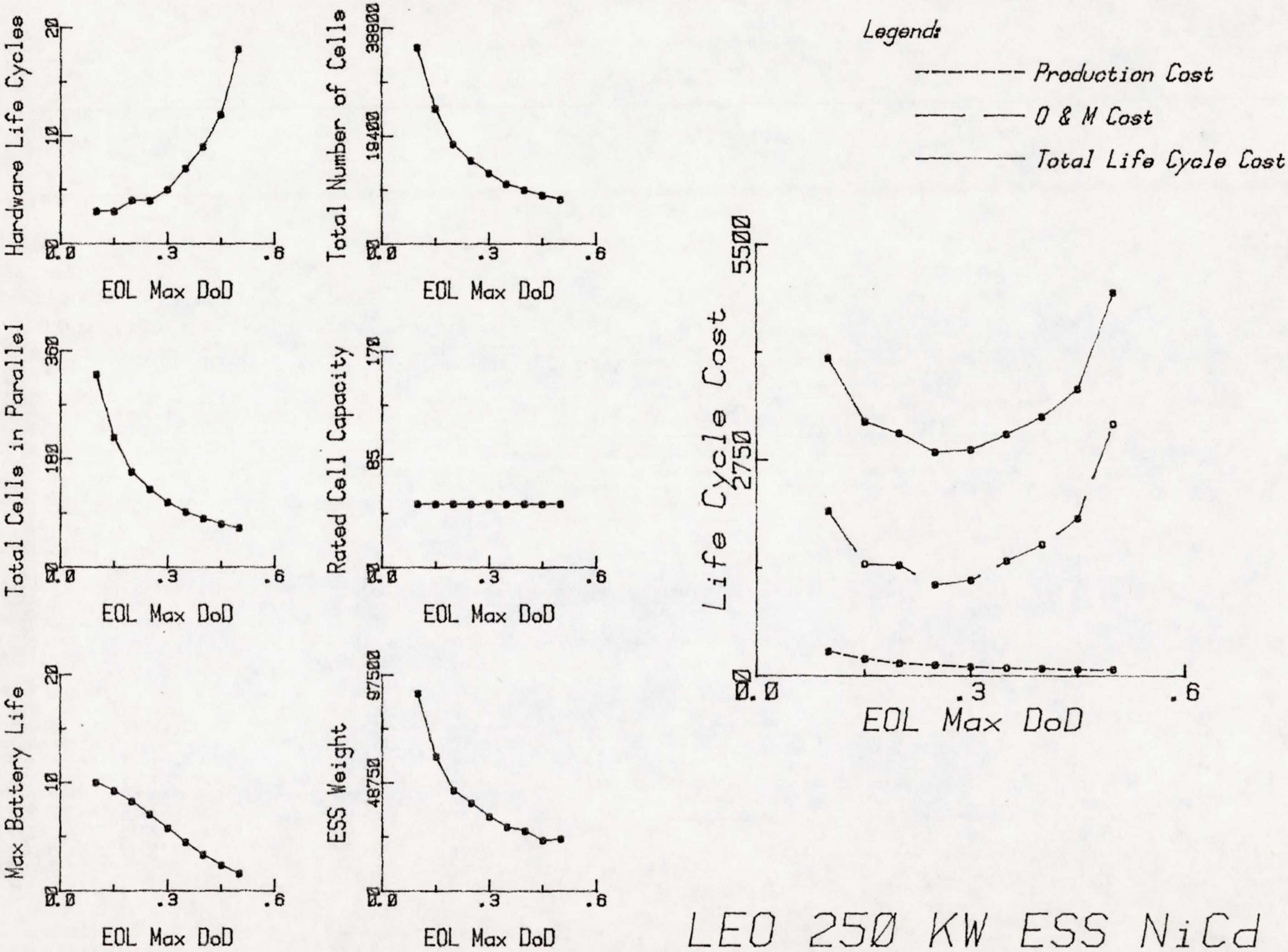

Exhibit 3d. Depth of Discharge (Capacity Fixed) Continued

GEO 25KW ESS (NiCd)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	1	1	1	1	1	1	1	1	1
Maximum Battery Life (Yr)	10.025	9.225	8.265	7.053	5.754	4.467	3.318	2.368	1.602
Rated Cell Capacity (AH)	50	50	50	50	50	50	50	50	50
Maximum Depth of Discharge	.100	.150	.200	.250	.300	.350	.400	.450	.500
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	4.211	6.259	8.270	10.526	12.188	14.473	16.541	17.813	19.297
Minimum Voltage (V)	1.321	1.296	1.284	1.272	1.262	1.250	1.238	1.228	1.217
Recharge Fraction	1.265	1.214	1.165	1.127	1.100	1.082	1.068	1.059	1.049
Charge Current (A)	.277	.395	.501	.617	.697	.814	.918	.981	1.053
Charge Voltage (V)	1.382	1.384	1.386	1.388	1.389	1.391	1.393	1.395	1.398
Watt-Hour Efficiency	.755	.771	.795	.813	.826	.831	.832	.831	.830
PHYSICAL CHARACTERISTICS									
Total Number of Cells	5390	3700	2828	2244	1957	1664	1470	1365	1272
Number of Parallel Batteries	55	37	28	22	19	16	14	13	12
Number of Modules per Battery	8	8	6	8	6	8	8	8	6
Battery Cell Weight (Kg)	2.027	2.027	2.027	2.027	2.027	2.027	2.027	2.027	2.027
Battery Cell Volume (Cm^3)	725	725	725	725	725	725	725	725	725
ESS Weight (Kg)	13536	9941	6983	6117	5352	4159	3687	3742	3193
ESS Volume (M^3)	107.110	76.509	47.384	45.906	35.538	30.604	29.608	29.608	22.491
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	20.517	16.186	13.785	12.288	11.487	10.607	10.057	9.814	9.476
Production Cost	204.550	150.567	107.979	94.337	83.085	66.128	59.130	59.481	51.810
Operations & Maintenance Cost	.500	.500	.500	.500	.500	.500	.500	.500	.500
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ESS LIFE CYCLE COST	225.567	167.253	122.264	107.125	95.072	77.235	69.687	69.795	61.786
Solar Array Cost	11.526	11.345	11.074	10.883	10.759	10.713	10.694	10.640	10.663
Thermal Control Cost	5.477	5.550	5.583	5.620	5.648	5.684	5.721	5.743	5.771
Power Conditioning Cost	5.982	4.274	3.375	2.750	2.429	2.100	1.875	1.761	1.645
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TOTAL LIFE CYCLE COST	248.552	188.422	142.296	126.378	113.908	95.732	87.977	87.939	79.865

Exhibit 3e. Depth of Discharge (Capacity Fixed)

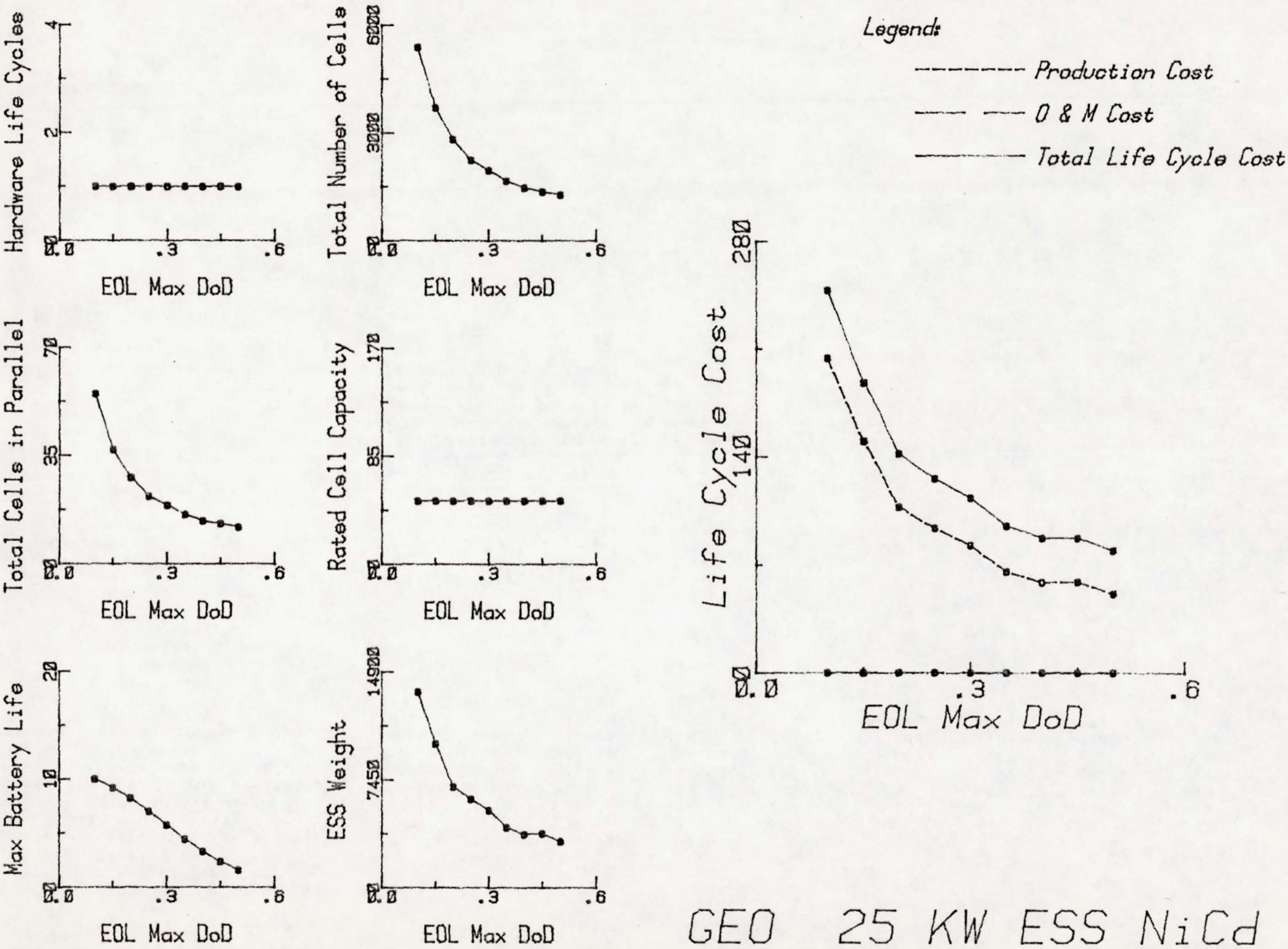

Exhibit 3e. Depth of Discharge (Capacity Fixed) Continued

LEO 25KW ESS (NICd)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	17	10	8	6	5	4	4	3	3
Maximum Battery Life (Yr)	1.700	2.800	3.900	5.000	6.100	7.200	8.300	9.400	10.500
Rated Cell Capacity (AH)	50	50	50	50	50	50	50	50	50
Maximum Depth of Discharge	.494	.426	.373	.330	.287	.244	.197	.141	.063
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	33.080	28.946	25.729	23.157	19.298	16.541	13.622	10.068	4.541
Minimum Voltage (V)	1.058	1.066	1.090	1.095	1.114	1.119	1.150	1.151	1.215
Recharge Fraction	1.005	1.005	1.013	1.026	1.048	1.067	1.087	1.133	1.255
Charge Current (A)	22.816	19.964	17.889	16.314	13.887	12.115	10.171	7.833	3.913
Charge Voltage (V)	1.713	1.699	1.667	1.666	1.651	1.652	1.616	1.630	1.580
Watt-Hour Efficiency	.615	.625	.646	.641	.644	.635	.655	.623	.613
PHYSICAL CHARACTERISTICS									
Total Number of Cells	854	968	1071	1180	1392	1624	1904	2576	5457
Number of Parallel Batteries	7	8	9	10	12	14	17	23	51
Number of Modules per Battery	8	8	6	6	6	8	6	8	8
Battery Cell Weight (Kg)	2.027	2.027	2.027	2.027	2.027	2.027	2.027	2.027	2.027
Battery Cell Volume (Cm^3)	725	725	725	725	725	725	725	725	725
ESS Weight (Kg)	2227	2499	3061	2994	3509	4087	5036	6675	14769
ESS Volume (M^3)	14.804	15.302	20.580	20.580	22.491	29.608	33.737	45.906	107.110
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	8.770	9.142	9.534	9.812	10.479	11.208	12.092	14.097	22.429
Production Cost	12.365	13.348	14.883	15.143	16.989	19.049	22.029	27.886	55.077
Operations & Maintenance Cost	308.970	203.067	149.884	121.609	118.756	131.994	128.827	156.465	337.385
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ESS LIFE CYCLE COST	330.105	225.557	174.301	146.564	146.224	162.251	162.948	198.448	414.891
Solar Array Cost	238.100	234.924	229.794	230.599	229.643	233.020	226.048	235.305	240.176
Thermal Control Cost	7.148	7.087	6.913	7.014	7.059	7.226	7.061	7.515	7.879
Power Conditioning Cost	1.042	1.166	1.289	1.409	1.645	1.875	2.210	2.856	5.611
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TOTAL LIFE CYCLE COST	576.395	468.734	412.297	385.586	384.571	404.372	398.267	444.124	668.557

Exhibit 4a. Cell Life (Capacity Fixed)

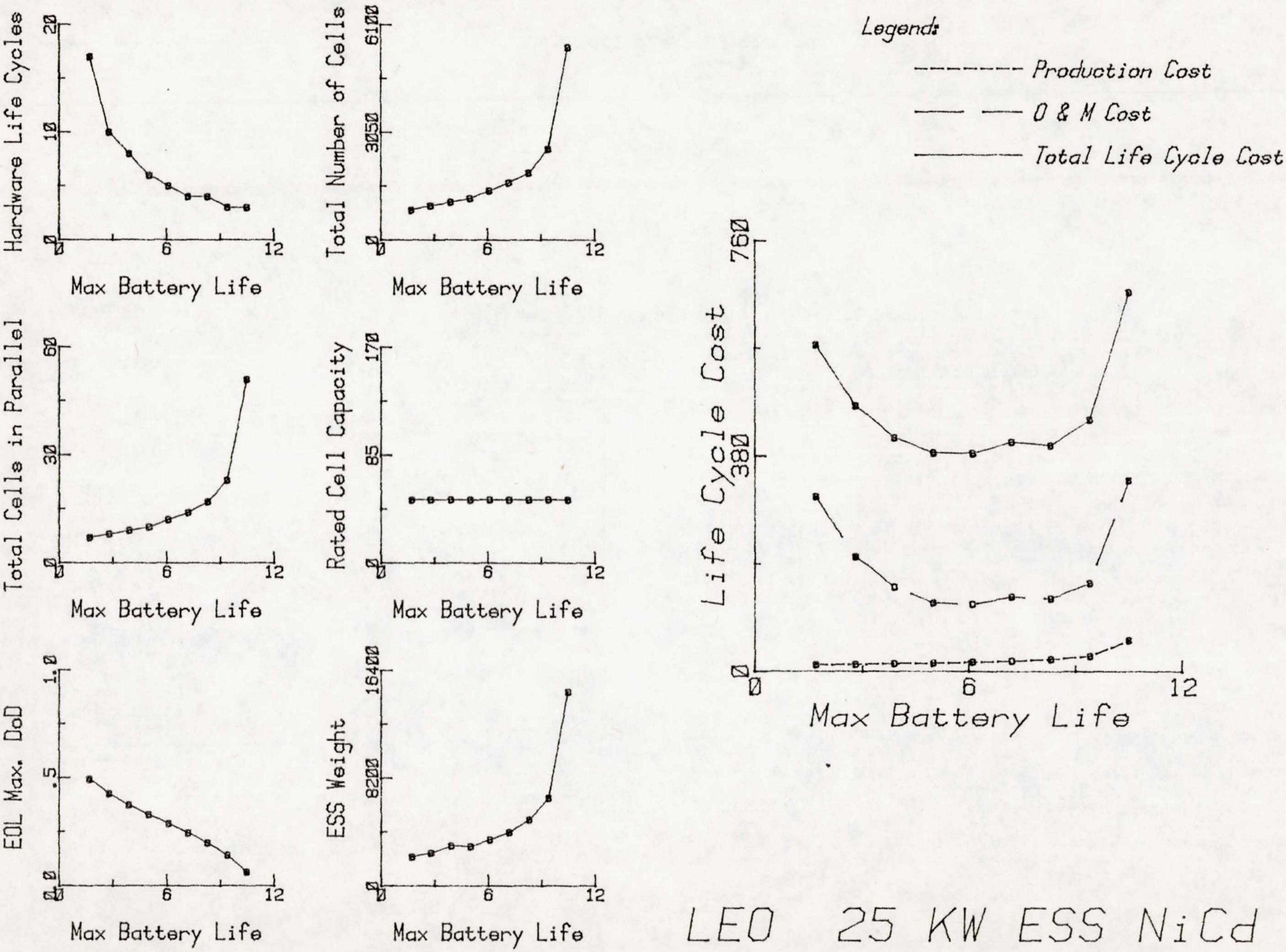

Exhibit 4a. Cell Life (Capacity Fixed) Continued

LEO 50KW ESS (NiCd)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	17	10	8	6	5	4	4	3	3
Maximum Battery Life (Yr)	1.700	2.800	3.900	5.000	6.100	7.200	8.300	9.400	10.500
Rated Cell Capacity (AH)	50	50	50	50	50	50	50	50	50
Maximum Depth of Discharge	.494	.426	.373	.330	.287	.244	.197	.141	.063
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	33.080	28.946	25.729	23.157	20.137	17.154	14.034	10.068	4.541
Minimum Voltage (V)	1.058	1.066	1.090	1.095	1.111	1.117	1.149	1.151	1.215
Recharge Fraction	1.005	1.005	1.013	1.026	1.043	1.062	1.084	1.133	1.255
Charge Current (A)	22.816	19.964	17.889	16.314	14.421	12.512	10.449	7.833	3.913
Charge Voltage (V)	1.713	1.699	1.667	1.666	1.653	1.654	1.617	1.630	1.580
Watt-Hour Efficiency	.615	.625	.646	.641	.644	.636	.655	.623	.613
PHYSICAL CHARACTERISTICS									
Total Number of Cells	1708	1936	2142	2360	2668	3132	3729	5152	10914
Number of Parallel Batteries	14	16	18	20	23	27	33	46	102
Number of Modules per Battery	8	8	8	8	8	8	8	8	8
Battery Cell Weight (Kg)	2.027	2.027	2.027	2.027	2.027	2.027	2.027	2.027	2.027
Battery Cell Volume (Cm^3)	725	725	725	725	725	725	725	725	725
ESS Weight (Kg)	4454	4996	5481	6324	7037	8201	9951	13349	27363
ESS Volume (M^3)	29.608	30.604	42.160	44.412	45.906	59.216	74.020	91.811	198.920
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	10.633	11.283	11.868	12.522	13.379	14.671	16.342	20.209	35.657
Production Cost	20.185	22.138	23.893	26.441	29.033	33.129	38.919	51.090	100.740
Operations & Maintenance Cost	585.087	386.269	343.223	282.105	267.033	247.979	299.615	307.980	669.731
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ESS LIFE CYCLE COST	615.905	419.690	378.984	321.068	309.445	295.779	354.876	379.279	806.128
Solar Array Cost	415.419	409.877	400.928	402.337	399.655	405.611	396.572	410.543	419.036
Thermal Control Cost	9.095	8.975	8.626	8.827	8.873	9.209	8.925	9.828	10.559
Power Conditioning Cost	1.875	2.100	2.320	2.537	2.856	3.272	3.879	5.141	10.100
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TOTAL LIFE CYCLE COST	1042.294	840.642	790.858	734.769	720.829	713.871	764.252	804.791	1245.823

Exhibit 4b. Cell Life (Capacity Fixed)

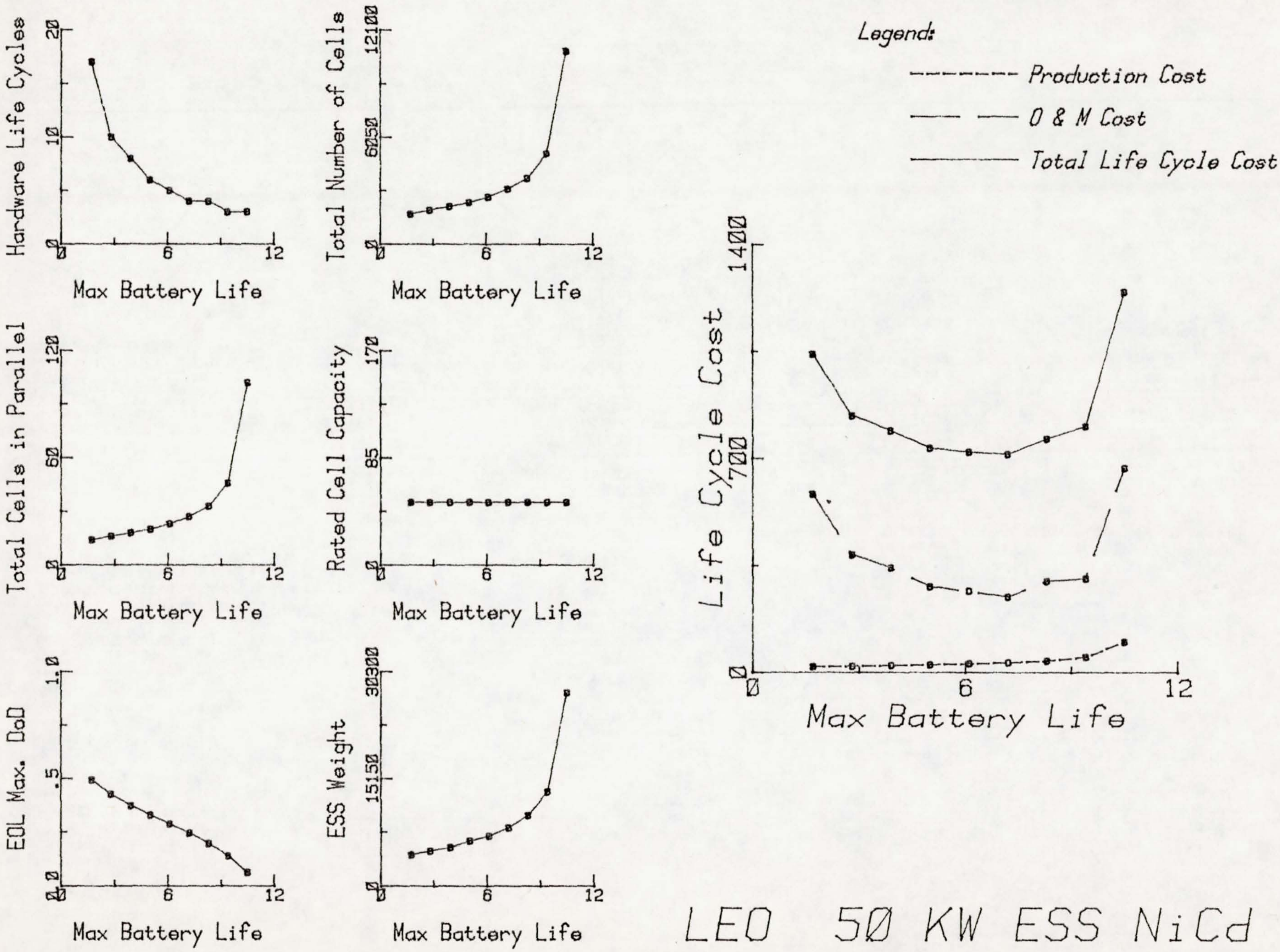

Exhibit 4b. Cell Life (Capacity Fixed) Continued

LEO 100KW ESS (NiCd)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	17	10	8	6	5	4	4	3	3
Maximum Battery Life (Yr)	1.700	2.800	3.900	5.000	6.100	7.200	8.300	9.400	10.500
Rated Cell Capacity (AH)	50	50	50	50	50	50	50	50	50
Maximum Depth of Discharge	.494	.426	.373	.330	.287	.244	.197	.141	.063
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	34.306	29.879	26.465	23.750	20.584	17.476	14.250	10.068	4.541
Minimum Voltage (V)	1.055	1.064	1.088	1.094	1.110	1.116	1.148	1.151	1.215
Recharge Fraction	1.005	1.005	1.010	1.023	1.040	1.060	1.083	1.133	1.255
Charge Current (A)	23.662	20.608	18.344	16.674	14.705	12.720	10.595	7.833	3.913
Charge Voltage (V)	1.727	1.702	1.669	1.668	1.655	1.655	1.618	1.630	1.580
Watt-Hour Efficiency	.609	.622	.646	.642	.645	.637	.656	.623	.613
PHYSICAL CHARACTERISTICS									
Total Number of Cells	3321	3782	4165	4602	5265	6148	7345	10304	21828
Number of Parallel Batteries	27	31	35	39	45	53	65	92	204
Number of Modules per Battery	8	8	8	8	8	8	8	8	8
Battery Cell Weight (Kg)	2.027	2.027	2.027	2.027	2.027	2.027	2.027	2.027	2.027
Battery Cell Volume (Cm^3)	725	725	725	725	725	725	725	725	725
ESS Weight (Kg)	8995	10047	10674	12017	14165	16319	20298	26697	54726
ESS Volume (M^3)	59.216	61.208	74.020	76.509	91.811	107.110	137.720	183.620	397.850
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	14.181	15.380	16.357	17.518	19.273	21.563	24.712	32.288	61.929
Production Cost	35.602	39.440	42.112	46.477	53.316	60.956	73.501	97.322	196.226
Operations & Maintenance Cost	1097.436	731.862	651.932	540.252	514.318	480.076	582.767	610.981	1333.554
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ESS LIFE CYCLE COST	1147.219	786.682	710.401	604.247	586.907	562.595	680.980	740.591	1591.709
Solar Array Cost	734.224	721.153	698.498	700.553	701.129	706.794	691.414	716.293	731.094
Thermal Control Cost	13.299	12.879	11.998	12.383	12.559	13.172	12.623	14.456	15.918
Power Conditioning Cost	3.272	3.679	4.078	4.469	5.046	5.797	6.893	9.254	18.180
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TOTAL LIFE CYCLE COST	1898.014	1524.393	1424.975	1321.652	1305.641	1288.358	1391.910	1480.594	2356.901

Exhibit 4c. Cell Life (Capacity Fixed)

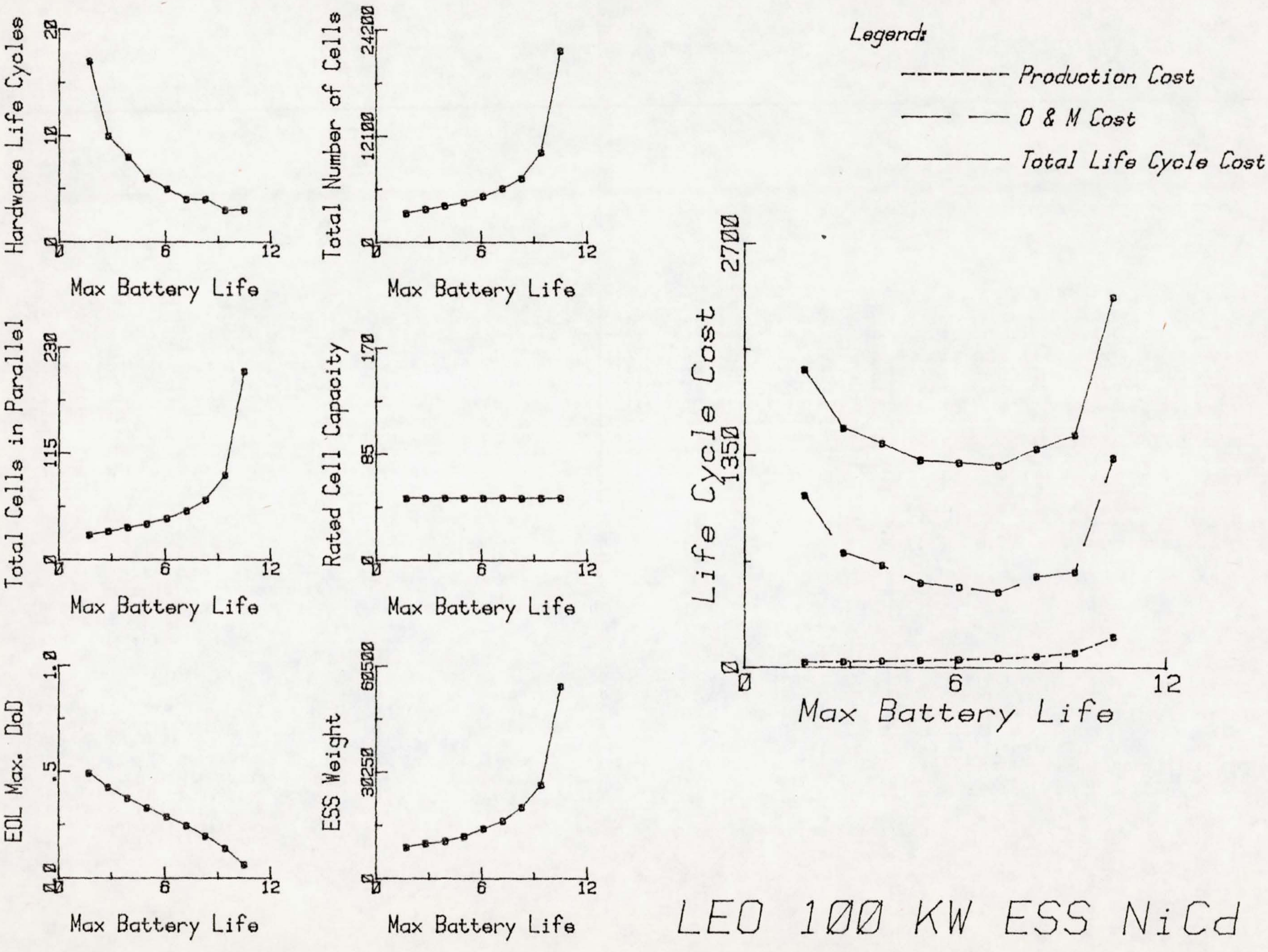

Exhibit 4c. Cell Life (Capacity Fixed) Continued

LEO 250KW ESS (NICd)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	17	10	8	6	5	4	4	3	3
Maximum Battery Life (Yr)	1.700	2.800	3.900	5.000	6.100	7.200	8.300	9.400	10.500
Rated Cell Capacity (AH)	50	50	50	50	50	50	50	50	50
Maximum Depth of Discharge	.494	.426	.373	.330	.287	.244	.197	.141	.063
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	35.085	30.470	26.927	23.630	20.676	17.410	14.294	10.068	4.541
Minimum Voltage (V)	1.054	1.063	1.088	1.094	1.109	1.117	1.148	1.151	1.215
Recharge Fraction	1.005	1.005	1.008	1.023	1.040	1.061	1.082	1.133	1.255
Charge Current (A)	24.199	21.016	18.627	16.601	14.764	12.678	10.624	7.833	3.913
Charge Voltage (V)	1.735	1.705	1.670	1.668	1.655	1.654	1.618	1.630	1.580
Watt-Hour Efficiency	.605	.621	.646	.641	.644	.636	.656	.623	.613
PHYSICAL CHARACTERISTICS									
Total Number of Cells	8118	9272	10234	11564	13104	15428	18306	25760	54570
Number of Parallel Batteries	66	76	86	98	112	133	162	230	510
Number of Modules per Battery	10	8	8	8	8	8	8	8	8
Battery Cell Weight (Kg)	2.027	2.027	2.027	2.027	2.027	2.027	2.027	2.027	2.027
Battery Cell Volume (Cm^3)	725	725	725	725	725	725	725	725	725
ESS Weight (Kg)	23393	25092	26797	31135	33233	39715	47481	64566	
ESS Volume (M^3)	165.370	153.020	168.320	198.920	214.230	260.130	321.340	443.750	979.320
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	18.453	20.287	21.866	24.127	26.643	30.542	35.338	47.684	95.621
Production Cost	83.226	90.718	97.654	111.389	121.198	142.886	169.149	230.844	476.946
Operations & Maintenance Cost	3077.583	1763.667	1578.031	1338.111	1265.560	1192.581	1440.578	1518.138	3321.581
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ESS LIFE CYCLE COST	3179.262	1874.672	1697.551	1473.627	1413.401	1366.009	1645.065	1796.666	3894.148
Solar Array Cost	1538.596	1506.831	1456.555	1462.803	1463.043	1475.518	1442.767	1494.967	1525.909
Thermal Control Cost	25.832	24.504	22.114	23.190	23.578	25.153	23.738	28.338	31.991
Power Conditioning Cost	6.982	7.870	8.739	9.763	10.934	12.649	14.952	20.127	39.541
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TOTAL LIFE CYCLE COST	4750.672	3413.877	3184.959	2969.383	2910.956	2879.329	3126.522	3340.098	5491.589

Exhibit 4d. Cell Life (Capacity Fixed)

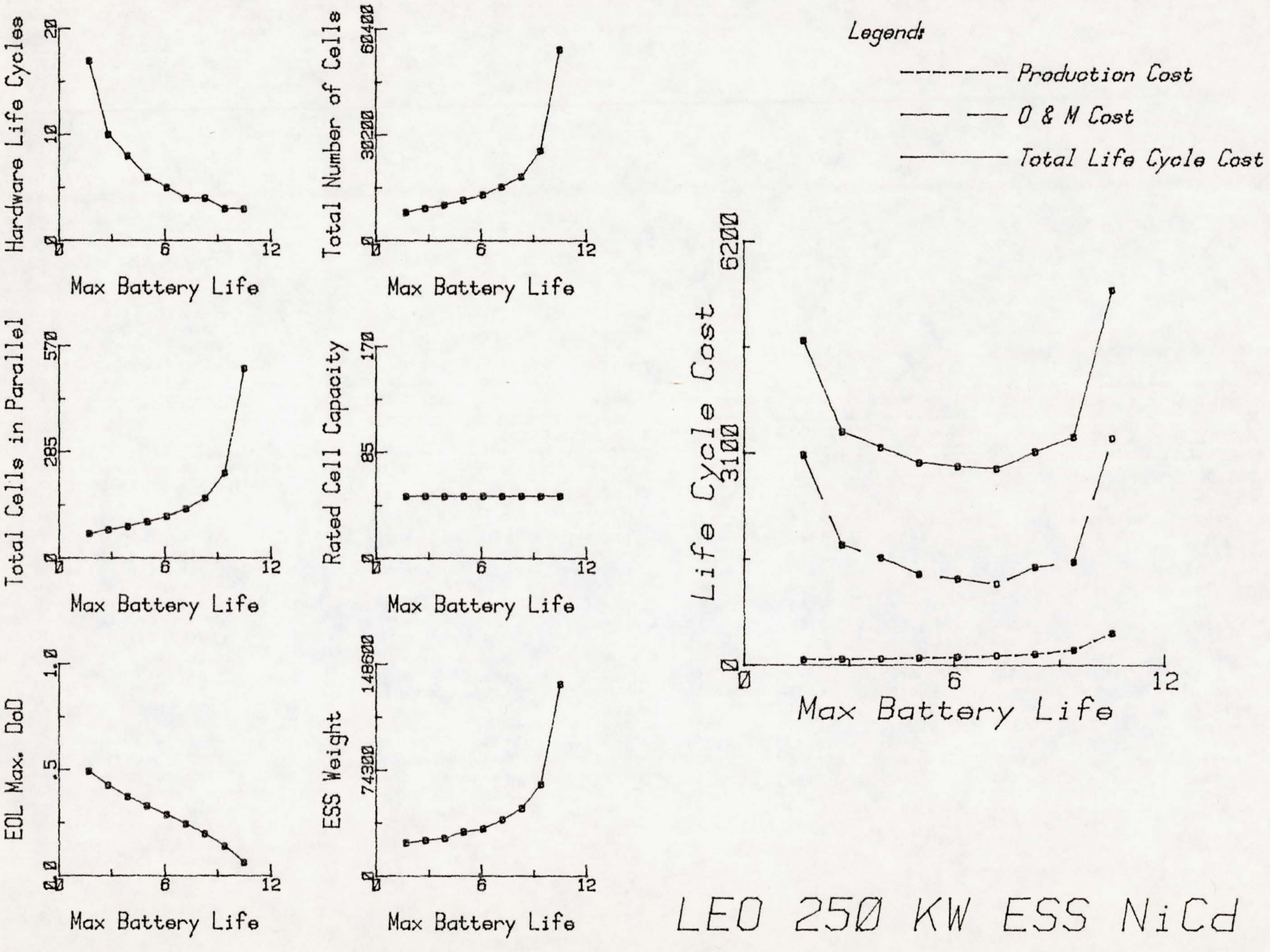

Exhibit 4d. Cell Life (Capacity Fixed) Continued

GEO 25KW ESS (NiCd)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	1	1	1	1	1	1	1	1	1
Maximum Battery Life (Yr)	1.700	2.800	3.900	5.000	6.100	7.200	8.300	9.400	10.500
Rated Cell Capacity (AH)	50	50	50	50	50	50	50	50	50
Maximum Depth of Discharge	.494	.426	.373	.330	.287	.244	.197	.141	.063
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	19.297	17.813	15.438	13.622	11.578	10.068	8.270	5.938	2.632
Minimum Voltage (V)	1.218	1.231	1.244	1.255	1.265	1.274	1.284	1.300	1.348
Recharge Fraction	1.049	1.059	1.075	1.088	1.110	1.135	1.165	1.222	1.306
Charge Current (A)	1.053	.981	.863	.771	.669	.594	.501	.378	.179
Charge Voltage (V)	1.398	1.394	1.392	1.390	1.388	1.387	1.386	1.384	1.381
Watt-Hour Efficiency	.830	.834	.832	.830	.821	.809	.796	.769	.748
PHYSICAL CHARACTERISTICS									
Total Number of Cells	1272	1365	1560	1751	2040	2346	2828	3900	8448
Number of Parallel Batteries	12	13	15	17	20	23	28	39	88
Number of Modules per Battery	6	8	8	6	6	8	6	8	8
Battery Cell Weight (Kg)	2.027	2.027	2.027	2.027	2.027	2.027	2.027	2.027	2.027
Battery Cell Volume (Cm^3)	725	725	725	725	725	725	725	725	725
ESS Weight (Kg)	3193	3742	4180	4644	5311	6093	6983	9884	20766
ESS Volume (M^3)	22.491	29.608	30.604	33.737	35.538	45.906	47.384	76.509	168.320
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	9.476	9.814	10.359	10.888	11.681	12.530	13.785	16.657	28.289
Production Cost	51.810	59.481	66.029	72.900	82.840	94.386	107.979	150.521	311.826
Operations & Maintenance Cost	.500	.500	.500	.500	.500	.500	.500	.500	.500
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ESS LIFE CYCLE COST	61.786	69.795	76.888	84.288	95.021	107.416	122.264	167.678	340.615
Solar Array Cost	10.660	10.634	10.665	10.680	10.762	10.937	11.076	11.422	11.634
Thermal Control Cost	5.771	5.738	5.698	5.667	5.636	5.614	5.583	5.538	5.402
Power Conditioning Cost	1.645	1.761	1.988	2.210	2.537	2.856	3.375	4.469	8.912
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TOTAL LIFE CYCLE COST	79.862	87.928	95.239	102.845	113.956	126.823	142.298	189.107	366.563

Exhibit 4e. Cell Life (Capacity Fixed)

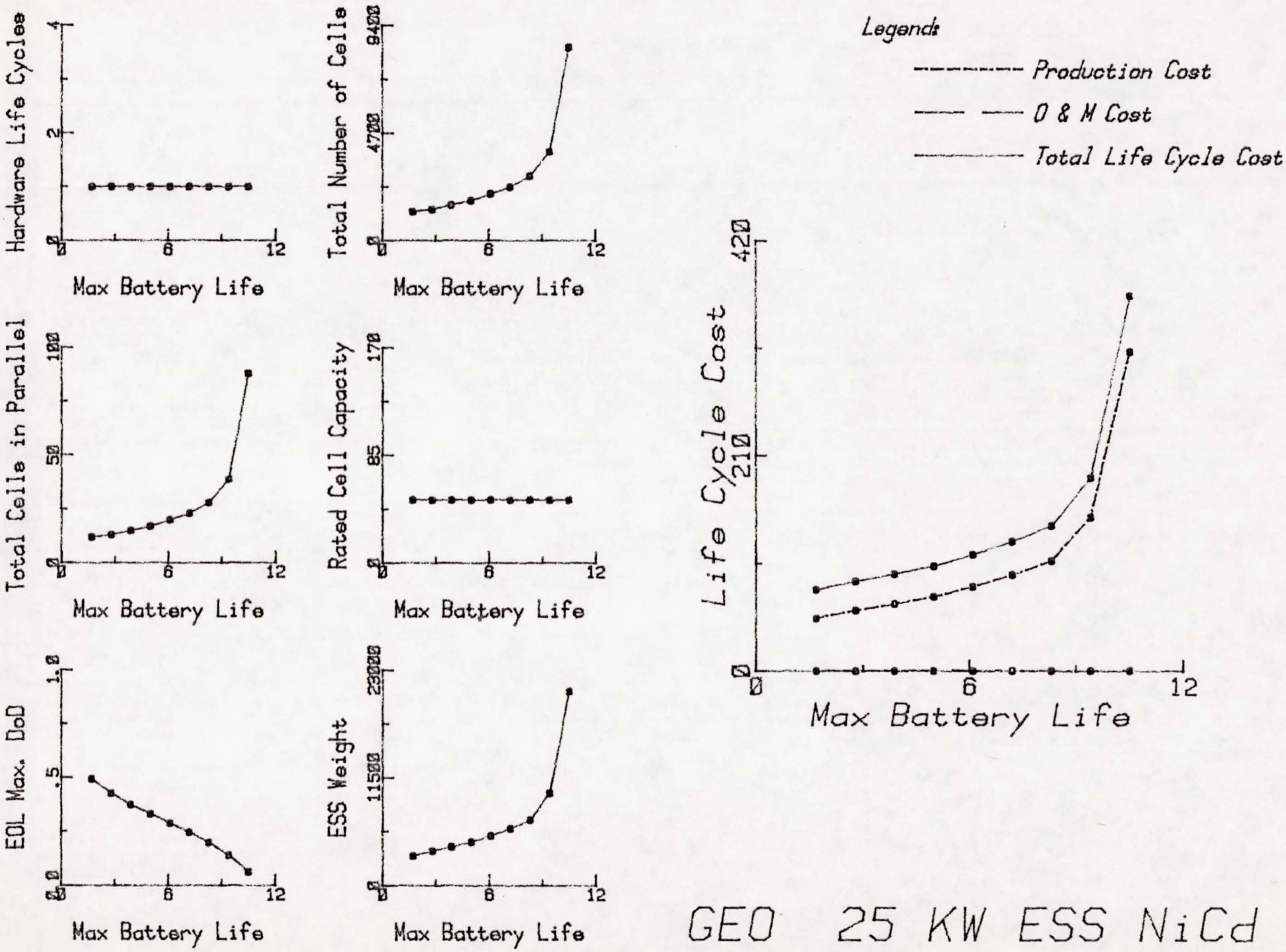

Exhibit 4e. Cell Life (Capacity Fixed) Continued

LEO 25KW ESS (NiCd)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	4	4	4	4	4	4	4	4	4
Maximum Battery Life (Yr)	6.983	7.096	6.983	7.204	7.572	7.397	8.297	8.833	9.203
Rated Cell Capacity (AH)	20	50	80	110	140	170	200	230	260
Maximum Depth of Discharge	.253	.248	.253	.244	.229	.236	.199	.172	.151
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	7.237	17.813	28.946	38.594	46.313	57.892	57.892	57.892	57.892
Minimum Voltage (V)	1.110	1.113	1.110	1.116	1.127	1.122	1.148	1.165	1.176
Recharge Fraction	1.056	1.058	1.056	1.060	1.067	1.063	1.081	1.095	1.115
Charge Current (A)	5.246	12.937	20.982	28.076	33.914	42.259	42.978	43.511	44.338
Charge Voltage (V)	1.663	1.659	1.663	1.655	1.642	1.648	1.619	1.602	1.590
Watt-Hour Efficiency	.632	.635	.632	.637	.644	.640	.656	.664	.663
PHYSICAL CHARACTERISTICS									
Total Number of Cells	3744	1508	936	696	575	460	452	444	440
Number of Parallel Batteries	32	13	8	6	5	4	4	4	4
Number of Modules per Battery	6	8	10	8	10	8	8	8	8
Battery Cell Weight (Kg)	.845	2.027	3.210	4.392	5.574	6.757	7.939	9.121	10.303
Battery Cell Volume (Cm^3)	288	725	1164	1604	2044	2488	2916	3359	3803
ESS Weight (Kg)	4441	4116	3627	3611	3752	3608	4114	4603	5119
ESS Volume (M^3)	34.149	29.608	25.021	18.937	30.721	21.098	21.098	21.098	21.098
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	13.153	10.905	10.269	10.118	10.216	10.038	10.615	11.181	11.785
Production Cost	22.374	18.688	16.917	16.679	17.071	16.566	18.285	19.971	21.765
Operations & Maintenance Cost	204.740	122.975	100.544	73.550	76.252	60.549	64.696	68.772	73.110
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ESS LIFE CYCLE COST	240.267	152.568	127.730	100.347	103.539	87.153	93.596	99.924	106.660
Solar Array Cost	233.972	232.239	233.945	232.104	230.280	230.372	226.954	224.039	224.528
Thermal Control Cost	7.235	7.204	7.235	7.190	7.136	7.153	7.049	6.998	7.047
Power Conditioning Cost	3.779	1.761	1.166	.914	.783	.648	.648	.648	.648
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TOTAL LIFE CYCLE COST	485.253	393.772	370.076	340.555	341.738	325.326	328.247	331.609	338.883

Exhibit 5a. Rated Cell Capacity

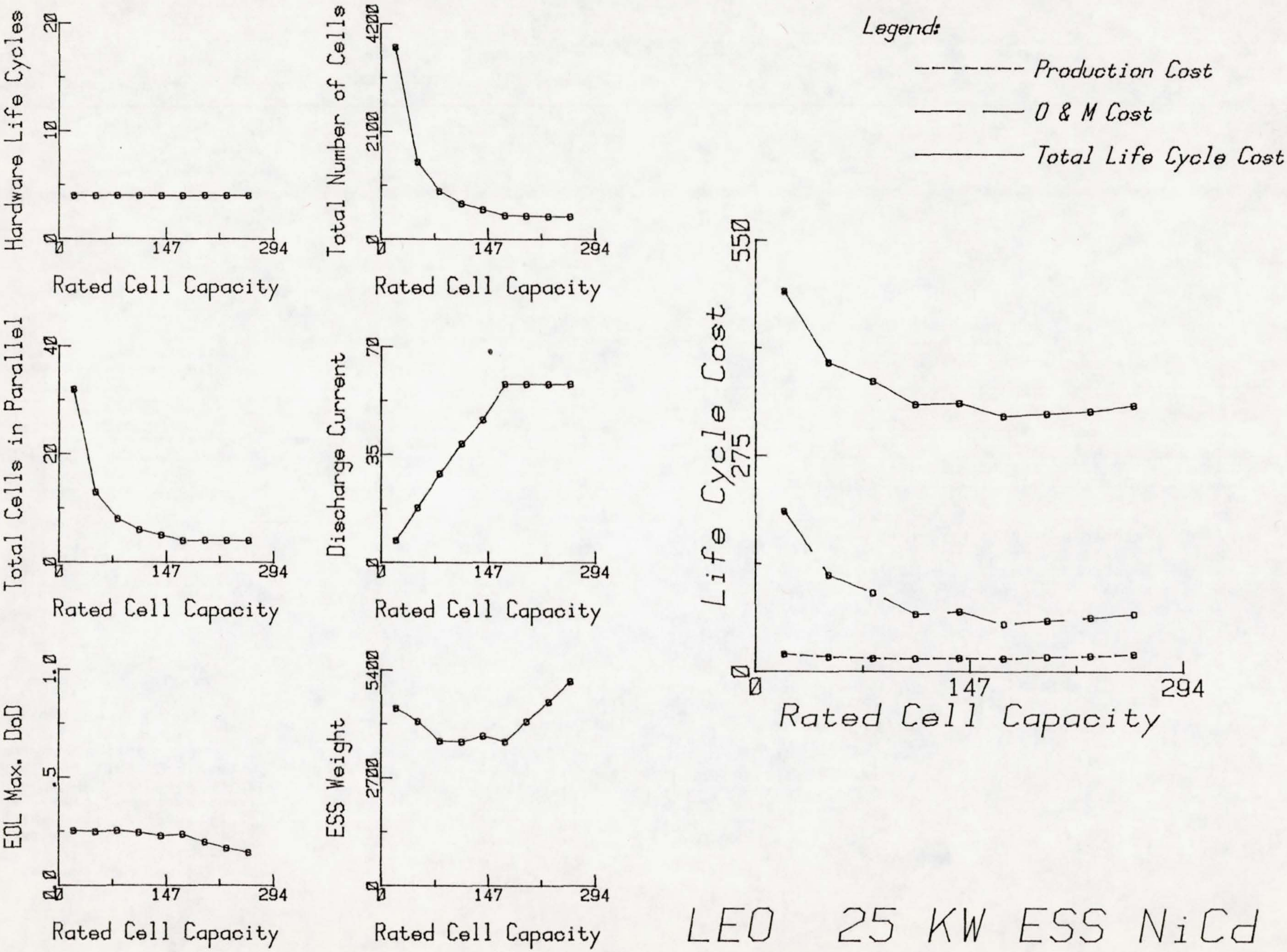

Exhibit 5a. Rated Cell Capacity (Continued)

LEO 50KW ESS (NiCd)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	4	4	4	4	4	4	4	4	4
Maximum Battery Life (Yr)	6.865	7.096	6.983	7.204	6.866	7.397	7.572	7.486	7.096
Rated Cell Capacity (AH)	20	50	80	110	140	170	200	230	260
Maximum Depth of Discharge	.257	.248	.253	.244	.257	.236	.229	.233	.248
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	7.352	17.813	28.946	38.594	51.459	57.892	66.160	77.188	92.625
Minimum Voltage (V)	1.106	1.113	1.110	1.116	1.106	1.122	1.127	1.125	1.113
Recharge Fraction	1.054	1.058	1.056	1.060	1.054	1.063	1.067	1.065	1.058
Charge Current (A)	5.320	12.937	20.982	28.076	37.234	42.259	48.448	56.434	67.267
Charge Voltage (V)	1.667	1.659	1.663	1.655	1.667	1.648	1.642	1.645	1.659
Watt-Hour Efficiency	.630	.635	.632	.637	.630	.640	.644	.642	.634
PHYSICAL CHARACTERISTICS									
Total Number of Cells	7371	3016	1872	1392	1053	920	805	690	580
Number of Parallel Batteries	63	26	16	12	9	8	7	6	5
Number of Modules per Battery	6	8	10	8	10	14	12	12	10
Battery Cell Weight (Kg)	.845	2.027	3.210	4.392	5.574	6.757	7.939	9.121	10.303
Battery Cell Volume (Cm^3)	288	725	1164	1604	2044	2488	2916	3359	3803
ESS Weight (Kg)	8900	8231	7253	7220	7908	7300	7428	7297	6908
ESS Volume (M^3)	68.297	59.216	50.041	37.874	61.442	49.967	41.854	39.732	30.721
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	18.433	14.383	13.241	12.952	12.617	12.854	12.999	12.901	12.563
Production Cost	39.826	32.780	29.257	28.782	29.639	28.799	29.252	28.859	27.626
Operations & Maintenance Cost	395.808	238.986	194.684	140.704	133.078	155.106	132.871	122.258	100.769
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ESS LIFE CYCLE COST	454.067	286.149	237.182	182.438	175.334	196.759	175.122	164.018	140.958
Solar Array Cost	408.499	405.188	408.175	404.958	408.447	401.936	401.771	401.852	405.169
Thermal Control Cost	9.304	9.207	9.270	9.179	9.304	9.104	9.071	9.088	9.207
Power Conditioning Cost	6.712	3.169	2.100	1.645	1.289	1.166	1.042	.914	.783
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TOTAL LIFE CYCLE COST	878.582	703.713	656.727	598.220	594.374	608.965	587.006	575.872	556.117

Exhibit 5b. Rated Cell Capacity

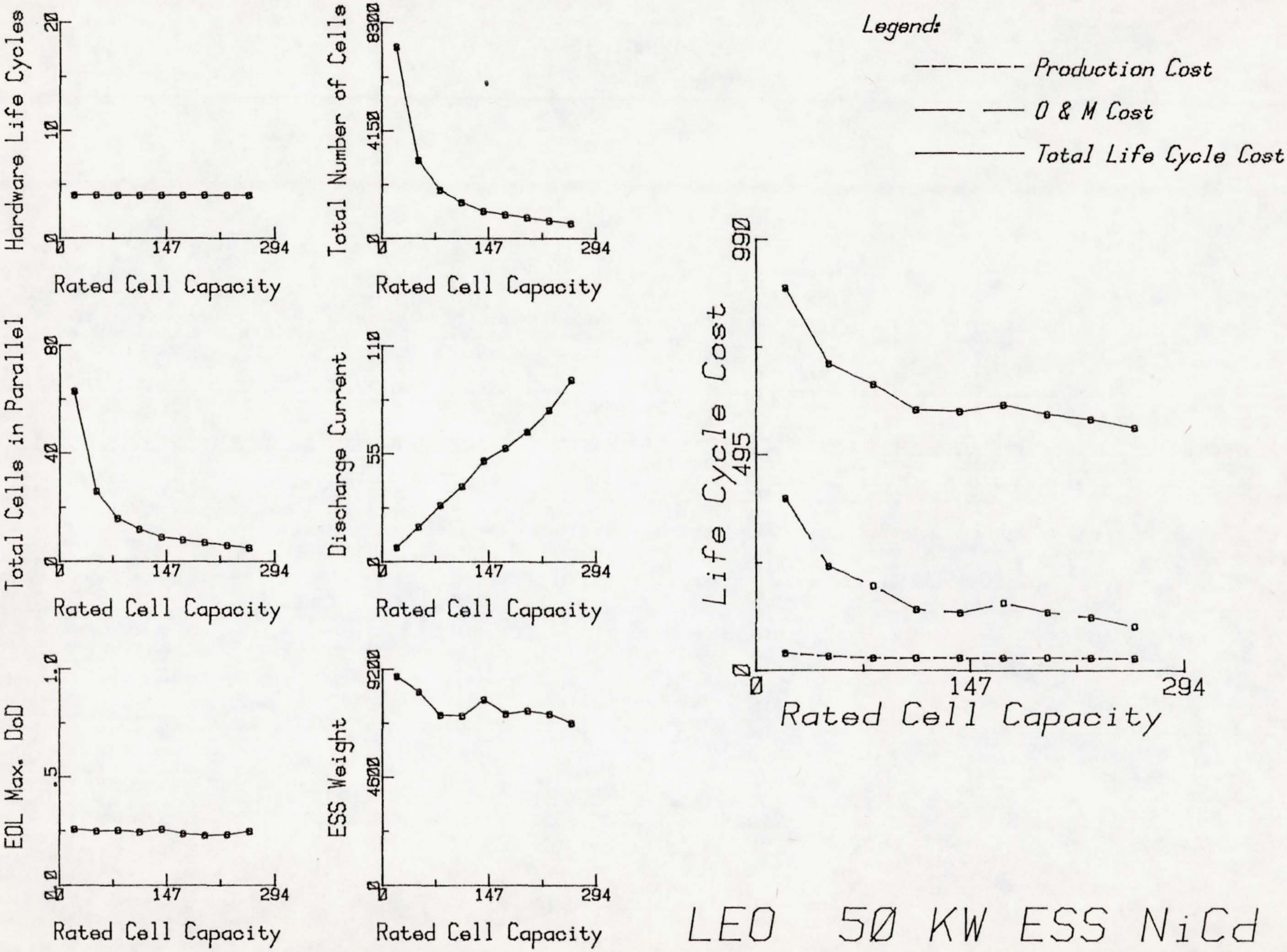

Exhibit 5b. Rated Cell Capacity (Continued)

LEO 100KW ESS (NiCd)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	4	4	4	4	4	4	4	4	4
Maximum Battery Life (Yr)	6.865	6.953	6.983	6.895	6.866	6.954	7.096	6.896	7.096
Rated Cell Capacity (AH)	20	50	80	110	140	170	200	230	260
Maximum Depth of Discharge	.257	.254	.253	.256	.257	.254	.248	.256	.248
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	7.352	18.163	28.946	40.272	51.459	61.750	71.251	84.204	92.625
Minimum Voltage (V)	1.106	1.109	1.110	1.107	1.106	1.109	1.113	1.107	1.113
Recharge Fraction	1.054	1.055	1.056	1.054	1.054	1.055	1.058	1.054	1.058
Charge Current (A)	5.320	13.160	20.982	29.154	37.234	44.743	51.746	60.955	67.267
Charge Voltage (V)	1.667	1.664	1.663	1.666	1.667	1.664	1.659	1.666	1.659
Watt-Hour Efficiency	.630	.632	.632	.630	.630	.632	.634	.630	.634
PHYSICAL CHARACTERISTICS									
Total Number of Cells	14742	5967	3744	2691	2106	1755	1508	1287	1160
Number of Parallel Batteries	126	51	32	23	18	15	13	11	10
Number of Modules per Battery	6	8	10	10	10	14	12	12	10
Battery Cell Weight (Kg)	.845	2.027	3.210	4.392	5.574	6.757	7.939	9.121	10.303
Battery Cell Volume (Cm^3)	288	725	1164	1604	2044	2488	2916	3359	3803
ESS Weight (Kg)	17799	16426	14505	14489	13821	14862	14848	14684	13815
ESS Volume (M^3)	136.590	107.110	100.080	75.062	100.720	99.935	83.708	79.465	61.442
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	29.008	21.126	19.170	18.246	17.789	17.878	17.900	17.682	17.847
Production Cost	74.727	60.534	53.844	52.460	50.461	52.664	52.669	52.023	50.534
Operations & Maintenance Cost	784.031	463.056	382.636	303.066	259.469	286.065	241.609	219.997	194.643
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ESS LIFE CYCLE COST	887.766	544.716	455.650	373.772	327.719	356.607	312.178	289.702	263.024
Solar Array Cost	712.734	712.325	712.161	712.530	712.612	712.243	706.917	712.489	706.917
Thermal Control Cost	13.408	13.358	13.340	13.391	13.407	13.356	13.215	13.389	13.214
Power Conditioning Cost	12.082	5.611	3.779	2.856	2.320	1.988	1.761	1.528	1.409
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TOTAL LIFE CYCLE COST	1625.990	1276.010	1184.930	1102.549	1056.058	1084.194	1034.071	1017.108	984.564

Exhibit 5c. Rated Cell Capacity

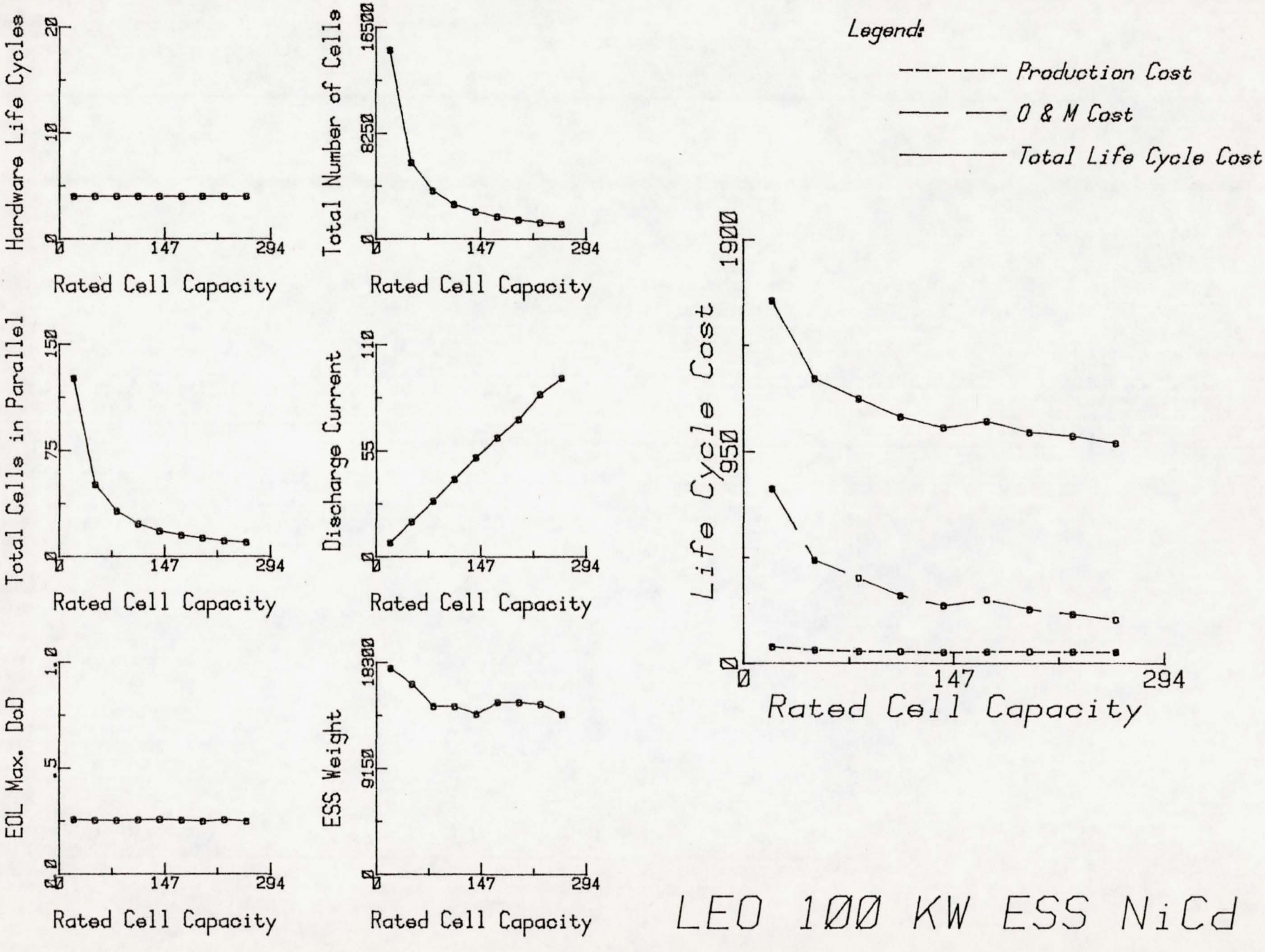

Exhibit 5c. Rated Cell Capacity (Continued)

LEO 250KW ESS (NiCd)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	4	4	4	4	4	4	4	4	4
Maximum Battery Life (Yr)	6.865	6.866	6.890	6.960	6.866	6.854	6.983	7.029	7.096
Rated Cell Capacity (AH)	20	50	80	110	140	170	200	230	260
Maximum Depth of Discharge	.257	.257	.256	.254	.257	.258	.253	.251	.248
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	7.352	18.379	29.312	39.925	51.459	62.584	72.364	82.701	92.625
Minimum Voltage (V)	1.106	1.106	1.107	1.109	1.106	1.106	1.110	1.111	1.113
Recharge Fraction	1.054	1.054	1.054	1.055	1.054	1.054	1.056	1.057	1.058
Charge Current (A)	5.320	13.298	21.217	28.932	37.234	45.275	52.455	59.992	67.267
Charge Voltage (V)	1.667	1.667	1.666	1.664	1.667	1.668	1.663	1.661	1.659
Watt-Hour Efficiency	.630	.630	.630	.632	.630	.629	.632	.633	.634
PHYSICAL CHARACTERISTICS									
Total Number of Cells	36855	14742	9243	6786	5265	4329	3744	3248	2900
Number of Parallel Batteries	315	126	79	58	45	37	32	28	25
Number of Modules per Battery	6	8	10	10	14	14	14	12	14
Battery Cell Weight (Kg)	.845	2.027	3.210	4.392	5.574	6.757	7.939	9.121	10.303
Battery Cell Volume (Cm^3)	288	725	1164	1604	2044	2488	2916	3359	3803
ESS Weight (Kg)	44496	37794	36284	38060	37498	37169	34863	34494	37838
ESS Volume (M^3)	341.490	244.830	250.210	200.170	299.800	249.840	199.870	167.420	193.370
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	42.436	29.387	26.392	25.363	24.608	24.268	24.377	24.250	24.636
Production Cost	178.776	136.460	126.772	128.061	125.249	123.832	119.437	118.411	125.997
Operations & Maintenance Cost	1945.975	1132.589	933.799	752.982	790.486	694.900	640.161	545.137	560.711
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ESS LIFE CYCLE COST	2167.187	1298.436	1086.963	906.406	940.343	843.000	783.975	687.798	711.344
Solar Array Cost	1487.523	1487.352	1487.113	1486.600	1487.318	1487.352	1486.395	1475.826	1475.415
Thermal Control Cost	25.719	25.715	25.682	25.586	25.717	25.729	25.553	25.320	25.235
Power Conditioning Cost	26.278	12.082	8.132	6.258	5.046	4.274	3.779	3.375	3.065
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TOTAL LIFE CYCLE COST	3706.707	2823.585	2607.890	2424.850	2458.424	2360.355	2299.702	2192.319	2215.059

Exhibit 5d. Rated Cell Capacity

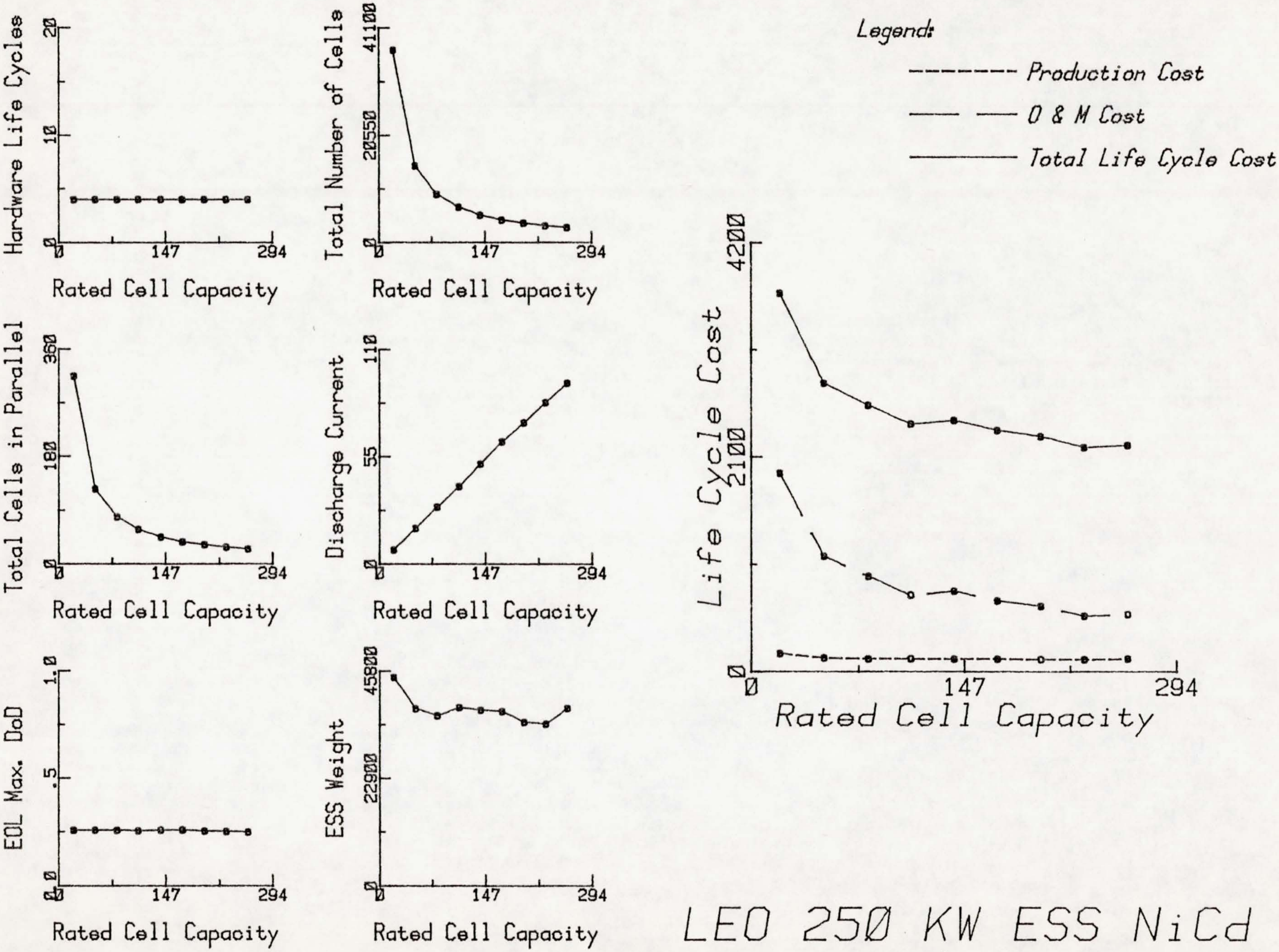

Exhibit 5d. Rated Cell Capacity (Continued)

GEO 25KW ESS (NiCd)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	1	1	1	1	1	1	1	1	1
Maximum Battery Life (Yr)	.802	1.011	.802	1.601	1.738	3.248	4.648	5.812	6.706
Rated Cell Capacity (AH)	20	50	80	110	140	170	200	230	260
Maximum Depth of Discharge	.576	.552	.576	.500	.491	.403	.343	.298	.263
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	9.649	23.156	38.594	46.312	57.890	57.890	57.890	57.890	57.890
Minimum Voltage (V)	1.186	1.195	1.186	1.211	1.213	1.235	1.251	1.261	1.269
Recharge Fraction	1.022	1.028	1.022	1.039	1.041	1.064	1.082	1.096	1.117
Charge Current (A)	.513	1.237	2.051	2.502	3.133	3.203	3.256	3.297	3.362
Charge Voltage (V)	1.408	1.404	1.408	1.399	1.398	1.393	1.391	1.389	1.388
Watt-Hour Efficiency	.824	.828	.824	.833	.833	.833	.831	.829	.818
PHYSICAL CHARACTERISTICS									
Total Number of Cells	2616	1080	654	535	428	420	412	412	408
Number of Parallel Batteries	24	10	6	5	4	4	4	4	4
Number of Modules per Battery	6	6	8	6	8	8	8	8	8
Battery Cell Weight (Kg)	.845	2.027	3.210	4.392	5.574	6.757	7.939	9.121	10.303
Battery Cell Volume (Cm^3)	288	725	1164	1604	2044	2488	2916	3359	3803
ESS Weight (Kg)	3139	2726	2534	2756	2780	3258	3717	4234	4707
ESS Volume (M^3)	25.611	20.580	18.937	13.641	21.098	21.098	21.098	21.098	21.098
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	10.355	8.912	8.451	8.617	8.600	9.103	9.589	10.146	10.662
Production Cost	52.430	44.882	41.698	44.828	45.743	52.095	58.816	66.413	73.385
Operations & Maintenance Cost	.500	.500	.500	.500	.500	.500	.500	.500	.500
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ESS LIFE CYCLE COST	63.285	54.294	50.649	53.945	54.843	61.698	68.905	77.059	84.547
Solar Array Cost	10.738	10.677	10.734	10.660	10.671	10.668	10.629	10.725	10.804
Thermal Control Cost	5.855	5.834	5.855	5.796	5.790	5.726	5.677	5.651	5.627
Power Conditioning Cost	2.961	1.409	.914	.783	.648	.648	.648	.648	.648
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TOTAL LIFE CYCLE COST	82.839	72.214	68.152	71.184	71.952	78.740	85.859	94.083	101.626

Exhibit 5e. Rated Cell Capacity

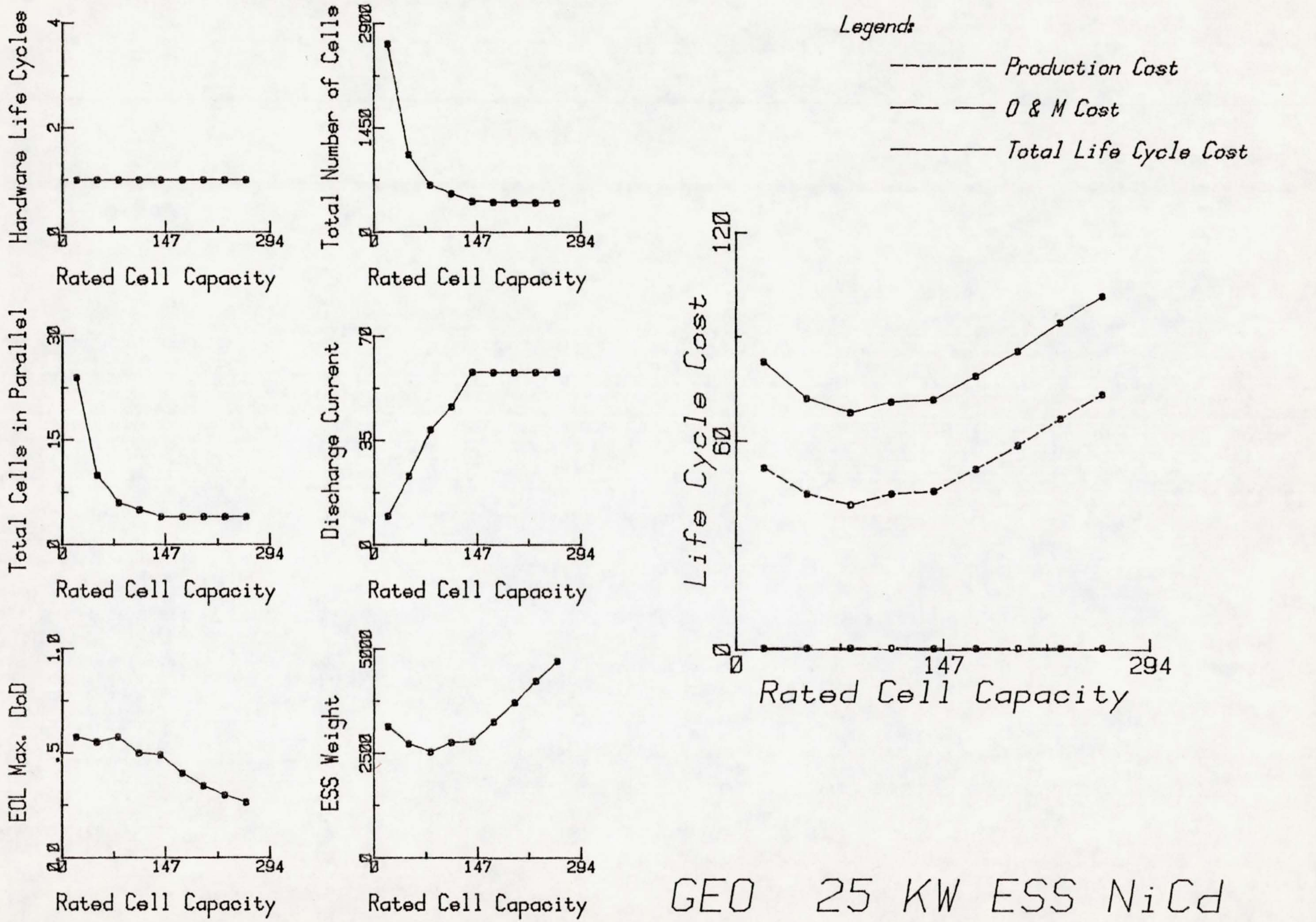

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Exhibit 5e. Rated Cell Capacity (Continued)

LEO 25KW ESS (NiCd)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	3	4	5	6	7	8	9	10	11
Maximum Battery Life (Yr)	9.226	7.203	5.799	4.830	4.991	3.715	3.844	3.939	3.189
Rated Cell Capacity (AH)	90	55	45	40	40	35	35	35	30
Maximum Depth of Discharge	.150	.244	.298	.336	.329	.382	.377	.373	.439
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	19.298	19.298	19.298	19.298	19.298	19.298	19.298	19.298	19.298
Minimum Voltage (V)	1.144	1.116	1.099	1.089	1.111	1.080	1.097	1.111	1.085
Recharge Fraction	1.123	1.060	1.036	1.021	1.020	1.005	1.005	1.005	1.005
Charge Current (A)	14.874	14.039	13.722	13.522	13.519	13.315	13.313	13.311	13.310
Charge Voltage (V)	1.636	1.655	1.667	1.676	1.643	1.681	1.655	1.635	1.670
Watt-Hour Efficiency	.623	.637	.637	.637	.663	.639	.660	.676	.646
PHYSICAL CHARACTERISTICS									
Total Number of Cells	1356	1392	1416	1428	1392	1440	1416	1392	1428
Number of Parallel Batteries	12	12	12	12	12	12	12	12	12
Number of Modules per Battery	8	6	6	6	6	6	6	6	6
Battery Cell Weight (Kg)	3.604	2.224	1.830	1.633	1.633	1.436	1.436	1.436	1.239
Battery Cell Volume (Cm^3)	1313	800	654	578	578	507	507	507	434
ESS Weight (Kg)	5739	3806	3266	2988	2913	2704	2657	2612	2379
ESS Volume (M^3)	37.874	22.491	22.491	22.491	22.491	22.491	22.491	22.491	15.681
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	12.616	10.769	10.257	9.993	9.893	9.718	9.655	9.593	9.380
Production Cost	24.075	17.929	16.243	15.381	15.111	14.499	14.328	14.165	13.463
Operations & Maintenance Cost	95.540	96.089	116.454	137.439	159.930	180.035	202.071	223.920	241.188
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ESS LIFE CYCLE COST	132.231	124.787	142.954	162.813	184.934	204.252	226.054	247.678	264.031
Solar Array Cost	235.939	232.131	232.433	232.217	223.887	231.543	225.478	220.269	228.692
Thermal Control Cost	7.505	7.191	7.106	7.052	6.762	6.964	6.734	6.563	6.807
Power Conditioning Cost	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645
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TOTAL LIFE CYCLE COST	377.320	365.754	384.138	403.727	417.228	444.404	459.911	476.155	501.175

Exhibit 6a. Hardware Life Cycles (Capacity Variable)

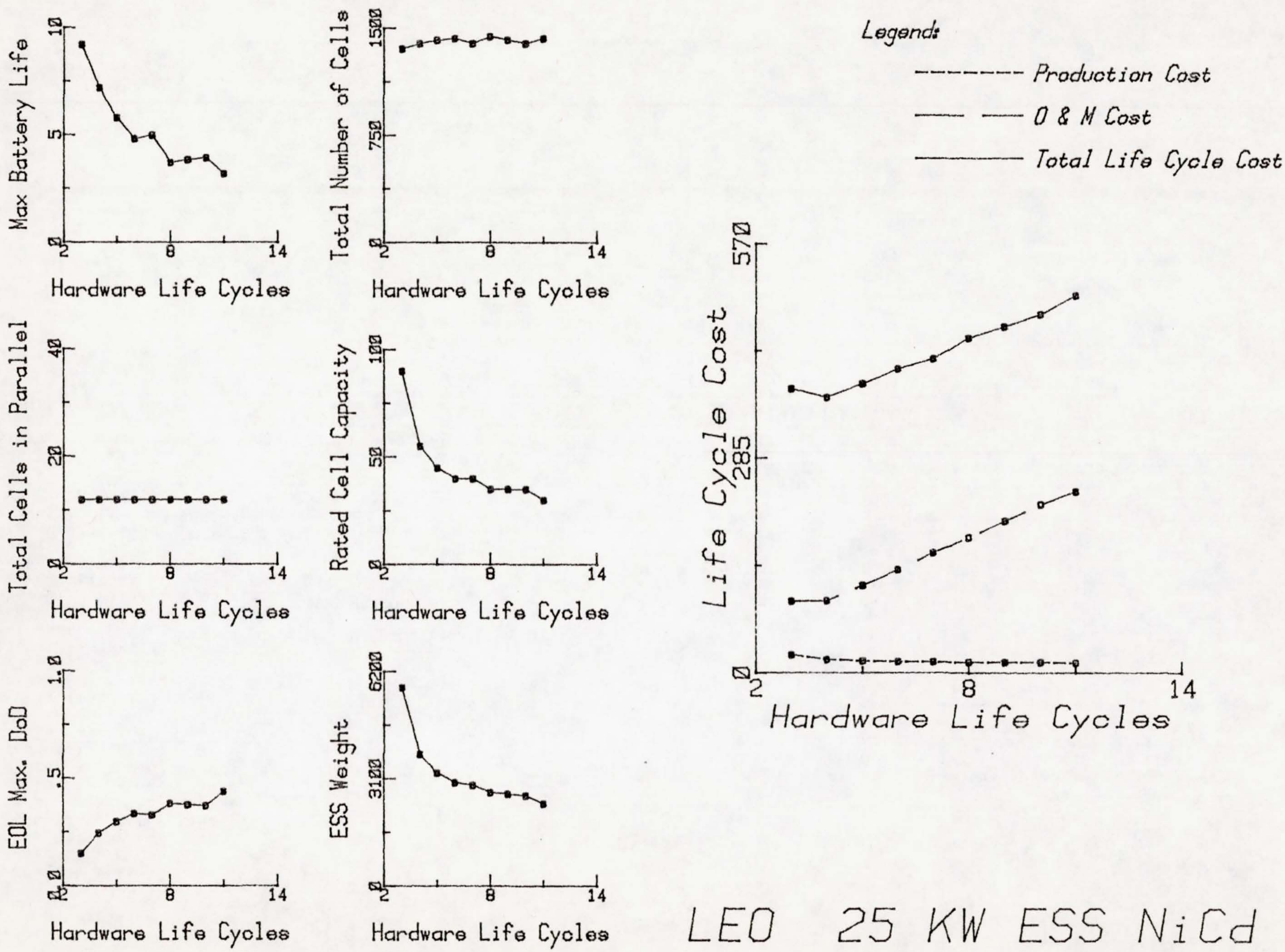

Exhibit 6a. Hardware Life Cycles (Capacity Variable) Continued

LEO 50KW ESS (NiCd)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	3	4	5	6	7	8	9	10	11
Maximum Battery Life (Yr)	9.153	6.866	5.799	4.830	4.318	3.715	3.418	3.111	2.775
Rated Cell Capacity (AH)	175	105	90	80	75	70	65	65	65
Maximum Depth of Discharge	.154	.257	.298	.336	.356	.382	.410	.410	.411
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	38.594	38.594	38.594	38.594	38.594	38.594	38.594	38.594	38.594
Minimum Voltage (V)	1.141	1.106	1.099	1.089	1.088	1.080	1.077	1.078	1.076
Recharge Fraction	1.117	1.054	1.036	1.021	1.012	1.005	1.005	1.005	1.005
Charge Current (A)	29.610	27.925	27.443	27.043	26.828	26.629	26.619	26.619	26.619
Charge Voltage (V)	1.639	1.667	1.667	1.676	1.672	1.681	1.683	1.681	1.685
Watt-Hour Efficiency	.623	.630	.637	.637	.643	.639	.637	.638	.636
PHYSICAL CHARACTERISTICS									
Total Number of Cells	1356	1404	1416	1428	1428	1440	1440	1440	1440
Number of Parallel Batteries	12	12	12	12	12	12	12	12	12
Number of Modules per Battery	10	8	8	8	8	8	8	8	8
Battery Cell Weight (Kg)	6.954	4.195	3.604	3.210	3.013	2.816	2.619	2.619	2.619
Battery Cell Volume (Cm^3)	2551	1533	1313	1164	1093	1015	944	944	944
ESS Weight (Kg)	10802	6988	6138	5581	5273	5011	4707	4706	4708
ESS Volume (M^3)	67.147	37.874	37.874	37.874	37.874	37.874	37.874	37.874	37.874
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	16.307	12.740	11.972	11.472	11.195	10.963	10.685	10.685	10.685
Production Cost	40.541	28.032	25.302	23.522	22.540	21.711	20.741	20.738	20.743
Operations & Maintenance Cost	136.618	138.904	168.065	196.738	226.457	255.432	282.318	314.387	346.453
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ESS LIFE CYCLE COST	193.466	179.676	205.339	231.732	260.192	288.106	313.744	345.810	377.881
Solar Array Cost	410.698	408.442	405.508	405.150	401.946	403.946	404.172	403.786	404.459
Thermal Control Cost	9.776	9.304	9.012	8.904	8.709	8.725	8.695	8.665	8.718
Power Conditioning Cost	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645
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TOTAL LIFE CYCLE COST	615.585	599.067	621.504	647.431	672.492	702.422	728.256	759.906	792.703

Exhibit 6b. Hardware Life Cycles (Capacity Variable)

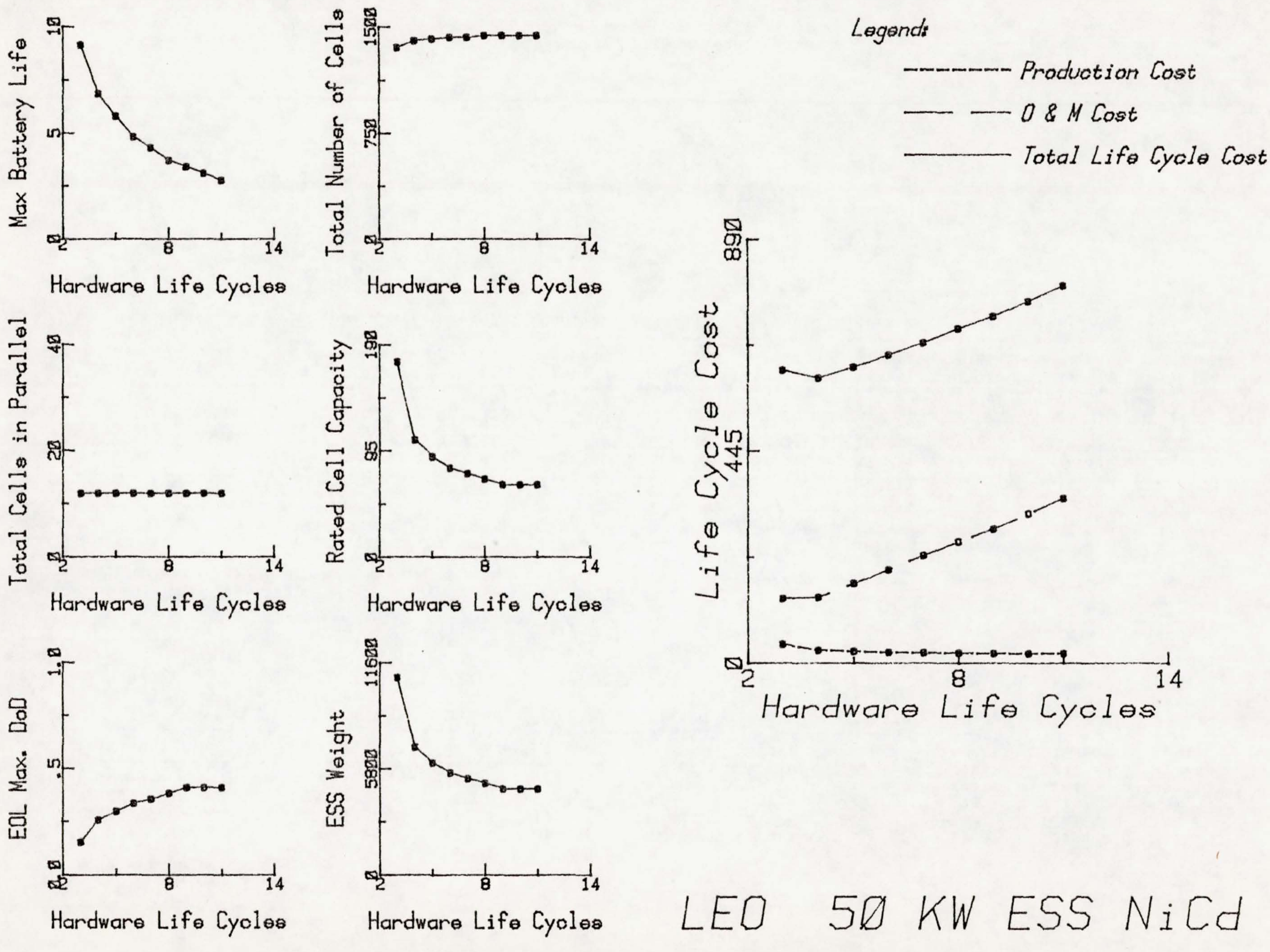

Exhibit 6b. Hardware Life Cycles (Capacity Variable) Continued

LEO 100KW ESS (NiCd)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	3	4	5	6	7	8	9	10	11
Maximum Battery Life (Yr)	9.153	6.866	5.536	4.830	3.946	3.715	3.202	2.900	2.798
Rated Cell Capacity (AH)	350	210	175	160	145	140	130	130	125
Maximum Depth of Discharge	.154	.257	.308	.336	.372	.382	.413	.413	.427
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	77.189	77.189	77.189	77.189	77.189	77.189	77.189	77.189	77.189
Minimum Voltage (V)	1.141	1.106	1.090	1.089	1.073	1.080	1.069	1.069	1.073
Recharge Fraction	1.117	1.054	1.032	1.021	1.009	1.005	1.005	1.005	1.005
Charge Current (A)	59.222	55.851	54.711	54.086	53.471	53.259	53.238	53.238	53.238
Charge Voltage (V)	1.639	1.667	1.678	1.676	1.693	1.681	1.696	1.694	1.688
Watt-Hour Efficiency	.623	.630	.629	.637	.628	.639	.627	.628	.633
PHYSICAL CHARACTERISTICS									
Total Number of Cells	1356	1404	1428	1428	1440	1440	1452	1452	1440
Number of Parallel Batteries	12	12	12	12	12	12	12	12	12
Number of Modules per Battery	12	12	12	12	12	12	8	8	8
Battery Cell Weight (Kg)	13.850	8.333	6.954	6.363	5.771	5.574	5.180	5.180	4.983
Battery Cell Volume (Cm^3)	5111	3058	2551	2329	2108	2044	1895	1895	1824
ESS Weight (Kg)	21241	13667	11772	10852	10034	9711	9075	9073	8691
ESS Volume (M^3)	54.016	79.465	79.465	79.465	79.465	79.465	37.874	37.874	37.874
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	25.247	17.566	15.799	14.967	14.226	13.950	13.404	13.403	13.066
Production Cost	76.171	49.827	43.470	40.426	37.719	36.676	34.617	34.612	33.364
Operations & Maintenance Cost	209.293	229.418	272.537	319.072	362.286	410.736	363.805	405.945	438.715
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ESS LIFE CYCLE COST	310.711	296.811	331.806	374.465	414.231	461.362	411.826	453.960	485.145
Solar Array Cost	716.579	712.612	714.330	706.876	710.974	704.784	714.167	713.717	706.712
Thermal Control Cost	14.350	13.407	13.105	12.606	12.752	12.251	12.628	12.589	12.270
Power Conditioning Cost	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645
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TOTAL LIFE CYCLE COST	1043.285	1024.475	1060.886	1095.592	1139.602	1180.042	1140.266	1181.911	1205.772

Exhibit 6c. Hardware Life Cycles (Capacity Variable)

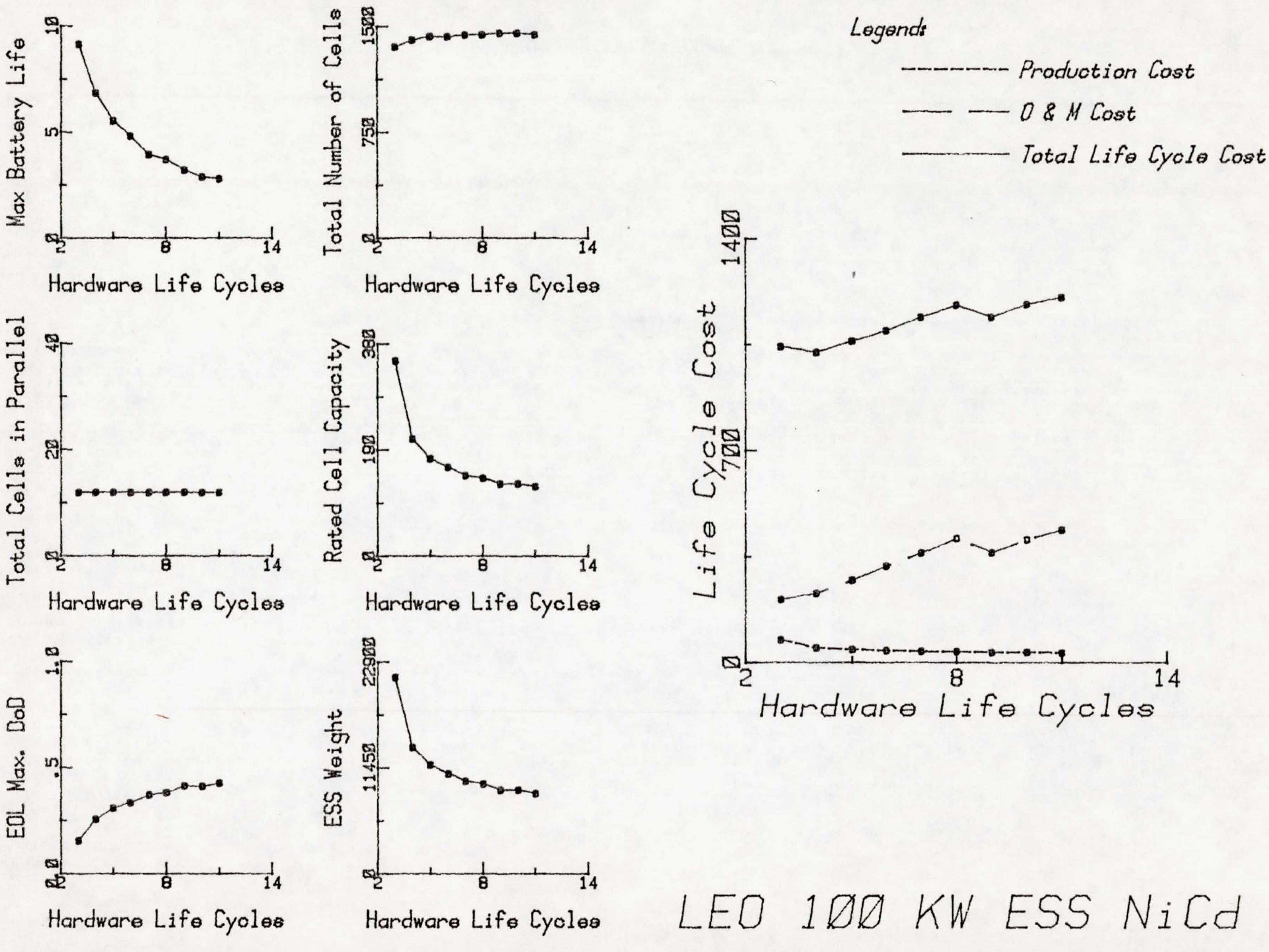

Exhibit 6c. Hardware Life Cycles (Capacity Variable) Continued

LEO 250KW ESS (NiCd)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	3	4	5	6	7	8	9	10	11
Maximum Battery Life (Yr)	9.168	6.937	5.591	4.689	4.173	3.541	3.159	2.948	2.706
Rated Cell Capacity (AH)	440	265	220	195	185	175	165	160	155
Maximum Depth of Discharge	.153	.254	.306	.345	.362	.384	.408	.419	.432
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	96.485	96.485	96.485	96.485	96.485	96.485	96.485	96.485	96.485
Minimum Voltage (V)	1.142	1.108	1.092	1.083	1.083	1.073	1.068	1.070	1.069
Recharge Fraction	1.118	1.055	1.033	1.017	1.011	1.005	1.005	1.005	1.005
Charge Current (A)	74.092	69.892	68.428	67.375	66.977	66.580	66.546	66.546	66.546
Charge Voltage (V)	1.638	1.665	1.676	1.683	1.680	1.691	1.697	1.693	1.695
Watt-Hour Efficiency	.623	.631	.631	.632	.637	.632	.627	.629	.628
PHYSICAL CHARACTERISTICS									
Total Number of Cells	2712	2808	2832	2856	2856	2904	2904	2904	2904
Number of Parallel Batteries	24	24	24	24	24	24	24	24	24
Number of Modules per Battery	16	12	12	12	12	12	12	12	12
Battery Cell Weight (Kg)	17.397	10.501	8.727	7.742	7.348	6.954	6.560	6.363	6.165
Battery Cell Volume (Cm^3)	6424	3866	3217	2852	2694	2551	2409	2329	2266
ESS Weight (Kg)	53467	34249	29131	26330	25096	24278	23068	22444	21836
ESS Volume (M^3)	140.320	158.930	158.930	158.930	158.930	158.930	158.930	158.930	158.930
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	37.392	24.238	21.048	19.360	18.638	18.149	17.431	17.073	16.718
Production Cost	185.764	117.893	100.509	91.129	87.046	84.316	80.294	78.247	76.240
Operations & Maintenance Cost	537.059	504.741	591.001	682.122	783.926	886.140	976.393	1074.611	1169.768
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ESS LIFE CYCLE COST	760.215	646.872	712.558	792.611	889.610	988.605	1074.118	1169.931	1262.726
Solar Array Cost	1496.093	1486.839	1479.762	1476.682	1467.364	1487.557	1491.144	1488.616	1490.085
Thermal Control Cost	28.101	25.626	24.673	23.976	23.172	23.686	23.889	23.508	23.546
Power Conditioning Cost	2.961	2.961	2.961	2.961	2.961	2.961	2.961	2.961	2.961
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TOTAL LIFE CYCLE COST	2287.370	2162.298	2219.954	2296.230	2383.107	2502.809	2592.112	2685.016	2779.318

Exhibit 6d. Hardware Life Cycles (Capacity Variable)

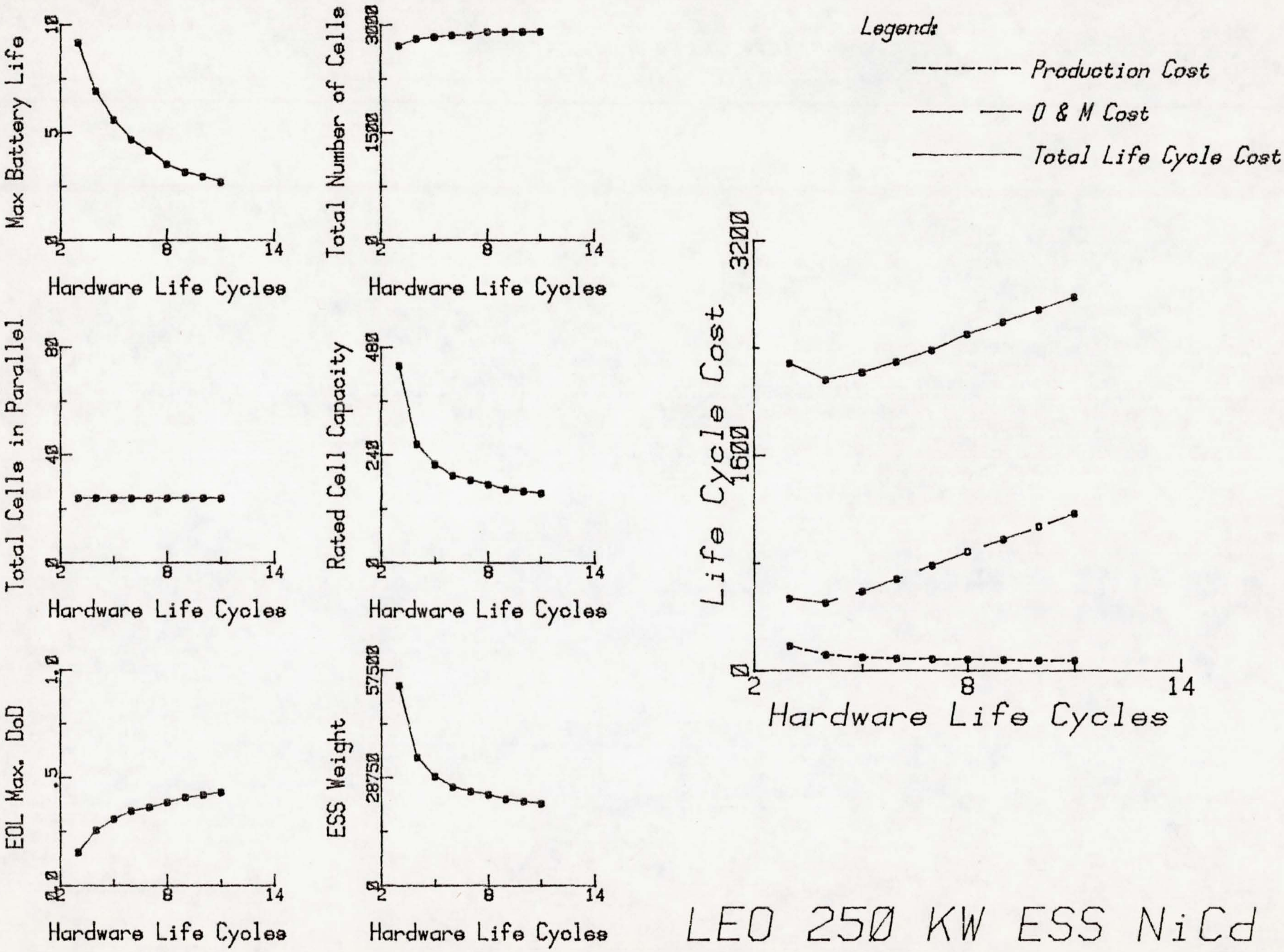

Exhibit 6d. Hardware Life Cycles (Capacity Variable) Continued

LEO 25KW ESS (NiCd)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	4	4	4	4	4	4	4	4	4
Maximum Battery Life (Yr)	7.527	6.946	7.162	6.946	7.078	6.946	6.945	6.946	6.870
Rated Cell Capacity (AH)	30	55	85	110	140	165	190	220	245
Maximum Depth of Discharge	.231	.254	.246	.254	.249	.254	.257	.254	.257
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	10.000	20.000	30.000	40.000	50.000	60.000	70.000	80.000	90.000
Minimum Voltage (V)	1.126	1.109	1.115	1.109	1.113	1.109	1.108	1.109	1.106
Recharge Fraction	1.066	1.055	1.059	1.055	1.057	1.055	1.054	1.055	1.054
Charge Current (A)	7.317	14.489	21.811	28.978	36.302	43.467	50.636	57.956	65.121
Charge Voltage (V)	1.643	1.664	1.656	1.664	1.659	1.664	1.665	1.664	1.667
Watt-Hour Efficiency	.643	.631	.636	.631	.634	.631	.631	.631	.630
PHYSICAL CHARACTERISTICS									
Total Number of Cells	2760	1404	928	702	580	468	468	468	468
Number of Parallel Batteries	24	12	8	6	5	4	4	4	4
Number of Modules per Battery	6	6	10	8	10	8	8	8	8
Battery Cell Weight (Kg)	1.239	2.224	3.407	4.392	5.574	6.560	7.545	8.727	9.712
Battery Cell Volume (Cm^3)	434	800	1235	1604	2044	2409	2773	3217	3581
ESS Weight (Kg)	4491	3844	3800	3648	3801	3578	4101	4723	5248
ESS Volume (M^3)	25.611	22.491	25.021	18.937	30.721	21.098	21.098	21.098	21.098
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	12.442	10.811	10.437	10.155	10.260	10.000	10.567	11.250	11.832
Production Cost	21.491	18.057	17.462	16.798	17.223	16.458	18.195	20.289	22.072
Operations & Maintenance Cost	163.235	96.348	101.804	73.793	76.529	60.238	64.264	69.160	73.320
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ESS LIFE CYCLE COST	197.168	125.216	129.703	100.746	104.012	86.696	93.026	100.699	107.224
Solar Array Cost	237.017	240.811	238.946	240.811	246.993	240.811	272.340	303.394	333.637
Thermal Control Cost	7.211	7.315	7.268	7.315	7.367	7.315	7.658	8.020	8.389
Power Conditioning Cost	2.961	1.645	1.166	.914	.783	.648	.648	.648	.648
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TOTAL LIFE CYCLE COST	444.357	374.987	377.083	349.786	359.155	335.470	373.672	412.761	449.893

Exhibit 7a. Discharge Current (Capacity Variable)

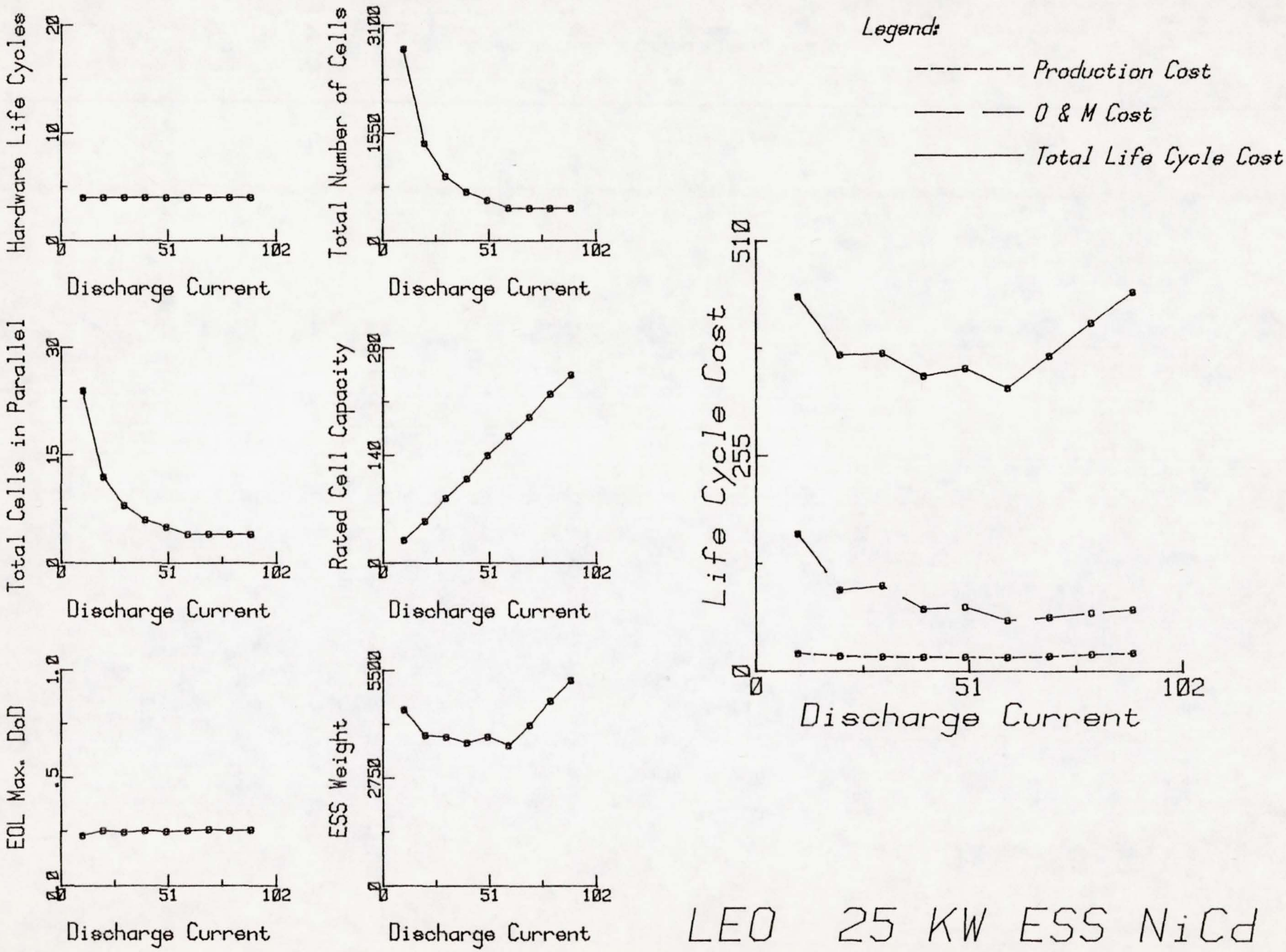

Exhibit 7a. Discharge Current (Capacity Variable) Continued

LEO 50KW ESS (NiCd)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	4	4	4	4	4	4	4	4	4
Maximum Battery Life (Yr)	7.527	6.946	7.162	6.946	7.078	6.946	6.945	6.946	6.870
Rated Cell Capacity (AH)	30	55	85	110	140	165	190	220	245
Maximum Depth of Discharge	.231	.254	.246	.254	.249	.254	.257	.254	.257
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	10.000	20.000	30.000	40.000	50.000	60.000	70.000	80.000	90.000
Minimum Voltage (V)	1.126	1.109	1.115	1.109	1.113	1.109	1.108	1.109	1.106
Recharge Fraction	1.066	1.055	1.059	1.055	1.057	1.055	1.054	1.055	1.054
Charge Current (A)	7.317	14.489	21.811	28.978	36.302	43.467	50.636	57.956	65.121
Charge Voltage (V)	1.643	1.664	1.656	1.664	1.659	1.664	1.665	1.664	1.667
Watt-Hour Efficiency	.643	.631	.636	.631	.634	.631	.631	.631	.630
PHYSICAL CHARACTERISTICS									
Total Number of Cells	5405	2808	1856	1404	1160	936	819	702	702
Number of Parallel Batteries	47	24	16	12	10	8	7	6	6
Number of Modules per Battery	6	8	10	8	10	14	12	12	12
Battery Cell Weight (Kg)	1.239	2.224	3.407	4.392	5.574	6.560	7.545	8.727	9.712
Battery Cell Volume (Cm^3)	434	800	1235	1604	2044	2409	2773	3217	3581
ESS Weight (Kg)	8945	7716	7599	7295	7602	7243	7237	7144	7938
ESS Volume (M^3)	51.223	45.906	50.041	37.874	61.442	49.967	41.854	39.732	39.732
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	17.033	14.260	13.535	13.018	13.192	12.788	12.783	12.719	13.521
Production Cost	37.931	31.603	30.346	29.021	29.864	28.593	28.575	28.305	30.984
Operations & Maintenance Cost	313.052	226.290	197.193	141.183	146.635	154.509	131.101	120.800	127.047
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ESS LIFE CYCLE COST	368.016	272.153	241.074	183.222	189.691	195.890	172.459	161.824	171.552
Solar Array Cost	406.602	420.150	416.890	420.150	430.930	420.150	426.841	420.154	462.035
Thermal Control Cost	9.137	9.430	9.337	9.430	9.532	9.430	9.503	9.430	9.983
Power Conditioning Cost	5.236	2.961	2.100	1.645	1.409	1.166	1.042	.914	.914
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TOTAL LIFE CYCLE COST	788.991	704.694	669.401	614.447	631.562	626.636	609.845	592.322	644.484

Exhibit 7b. Discharge Current (Capacity Variable)

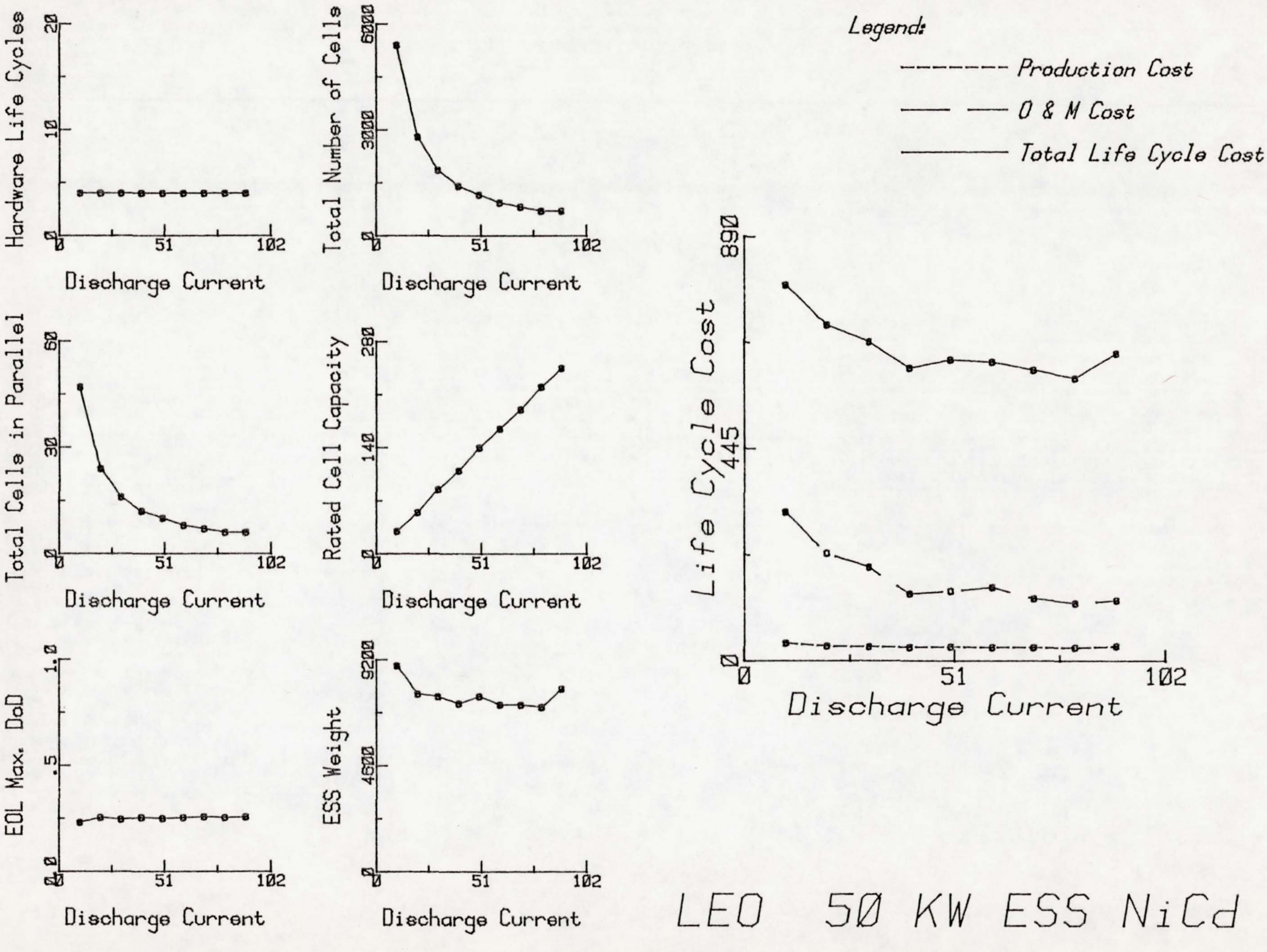

Exhibit 7b. Discharge Current (Capacity Variable) Continued

LEO 100KW ESS (NiCd)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	4	4	4	4	4	4	4	4	4
Maximum Battery Life (Yr)	7.527	6.946	7.162	6.946	7.078	6.946	6.945	6.946	6.870
Rated Cell Capacity (AH)	30	55	85	110	140	165	190	220	245
Maximum Depth of Discharge	.231	.254	.246	.254	.249	.254	.257	.254	.257
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	10.000	20.000	30.000	40.000	50.000	60.000	70.000	80.000	90.000
Minimum Voltage (V)	1.126	1.109	1.115	1.109	1.113	1.109	1.108	1.109	1.106
Recharge Fraction	1.066	1.055	1.059	1.055	1.057	1.055	1.054	1.055	1.054
Charge Current (A)	7.317	14.489	21.811	28.978	36.302	43.467	50.636	57.956	65.121
Charge Voltage (V)	1.643	1.664	1.656	1.664	1.659	1.664	1.665	1.664	1.667
Watt-Hour Efficiency	.643	.631	.636	.631	.634	.631	.631	.631	.630
PHYSICAL CHARACTERISTICS									
Total Number of Cells	10695	5499	3596	2808	2204	1872	1638	1404	1287
Number of Parallel Batteries	93	47	31	24	19	16	14	12	11
Number of Modules per Battery	6	8	10	10	12	14	12	12	12
Battery Cell Weight (Kg)	1.239	2.224	3.407	4.392	5.574	6.560	7.545	8.727	9.712
Battery Cell Volume (Cm^3)	434	800	1235	1604	2044	2409	2773	3217	3581
ESS Weight (Kg)	17853	15381	15166	14648	16244	14485	14472	14286	15555
ESS Volume (M^3)	102.450	91.811	100.080	75.062	125.560	99.935	83.708	79.465	79.465
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	26.127	20.786	19.292	18.774	18.504	18.284	18.267	18.142	18.497
Production Cost	70.660	57.949	55.340	53.549	56.340	52.508	52.456	51.903	54.952
Operations & Maintenance Cost	611.695	436.039	375.751	315.923	304.892	301.784	254.931	234.283	226.820
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ESS LIFE CYCLE COST	708.482	514.774	450.383	388.246	379.736	372.576	325.654	304.328	300.269
Solar Array Cost	703.347	720.745	709.049	733.046	721.521	733.046	744.729	733.046	751.726
Thermal Control Cost	12.989	13.483	13.215	13.657	13.431	13.657	13.804	13.659	13.969
Power Conditioning Cost	9.339	5.236	3.679	2.961	2.429	2.100	1.875	1.645	1.528
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TOTAL LIFE CYCLE COST	1434.157	1254.238	1176.326	1137.910	1117.117	1121.379	1086.062	1052.678	1067.492

Exhibit 7c. Discharge Current (Capacity Variable)

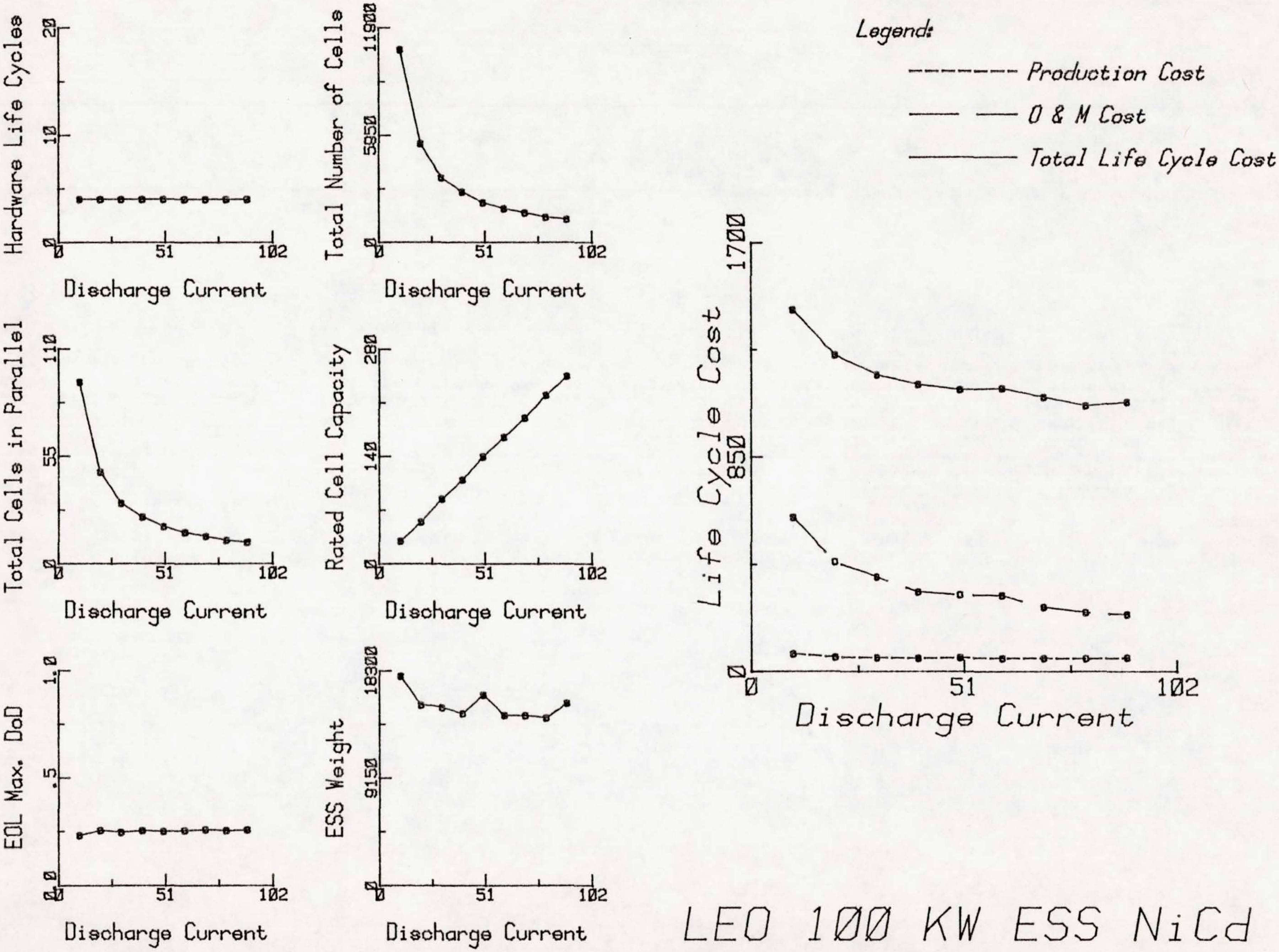

Exhibit 7c. Discharge Current (Capacity Variable) Continued

LEO 250KW ESS (NiCd)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	4	4	4	4	4	4	4	4	4
Maximum Battery Life (Yr)	7.527	6.946	7.162	6.946	7.078	6.946	6.945	6.946	6.870
Rated Cell Capacity (AH)	30	55	85	110	140	165	190	220	245
Maximum Depth of Discharge	.231	.254	.246	.254	.249	.254	.257	.254	.257
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	10.000	20.000	30.000	40.000	50.000	60.000	70.000	80.000	90.000
Minimum Voltage (V)	1.126	1.109	1.115	1.109	1.113	1.109	1.108	1.109	1.106
Recharge Fraction	1.066	1.055	1.059	1.055	1.057	1.055	1.054	1.055	1.054
Charge Current (A)	7.317	14.489	21.811	28.978	36.302	43.467	50.636	57.956	65.121
Charge Voltage (V)	1.643	1.664	1.656	1.664	1.659	1.664	1.665	1.664	1.667
Watt-Hour Efficiency	.643	.631	.636	.631	.634	.631	.631	.631	.630
PHYSICAL CHARACTERISTICS									
Total Number of Cells	26680	13572	9048	6786	5452	4563	3978	3393	3042
Number of Parallel Batteries	232	116	78	58	47	39	34	29	26
Number of Modules per Battery	6	8	10	10	14	14	12	14	14
Battery Cell Weight (Kg)	1.239	2.224	3.407	4.392	5.574	6.560	7.545	8.727	9.712
Battery Cell Volume (Cm^3)	434	800	1235	1604	2044	2409	2773	3217	3531
ESS Weight (Kg)	43400	38377	37929	38065	36903	36194	36017	37330	36550
ESS Volume (M^3)	247.580	229.530	250.210	200.170	299.800	249.840	209.270	199.870	193.370
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	37.705	28.933	26.966	25.364	25.247	24.692	24.575	24.384	24.355
Production Cost	166.145	136.628	131.358	128.073	125.474	122.813	122.196	124.414	122.780
Operations & Maintenance Cost	1513.384	1064.541	934.123	752.994	822.947	724.342	608.192	604.449	569.488
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ESS LIFE CYCLE COST	1717.234	1230.102	1092.447	906.431	973.668	871.847	754.963	753.247	716.623
Solar Array Cost	1465.410	1488.855	1487.523	1488.855	1493.158	1499.163	1518.571	1488.889	1499.845
Thermal Control Cost	24.631	25.640	25.367	25.640	25.560	25.816	26.096	25.640	25.926
Power Conditioning Cost	20.275	11.264	8.045	6.258	5.236	4.469	3.979	3.477	3.169
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TOTAL LIFE CYCLE COST	3227.550	2755.861	2613.382	2427.184	2497.622	2401.295	2303.609	2271.253	2245.563

Exhibit 7d. Discharge Current (Capacity Variable)

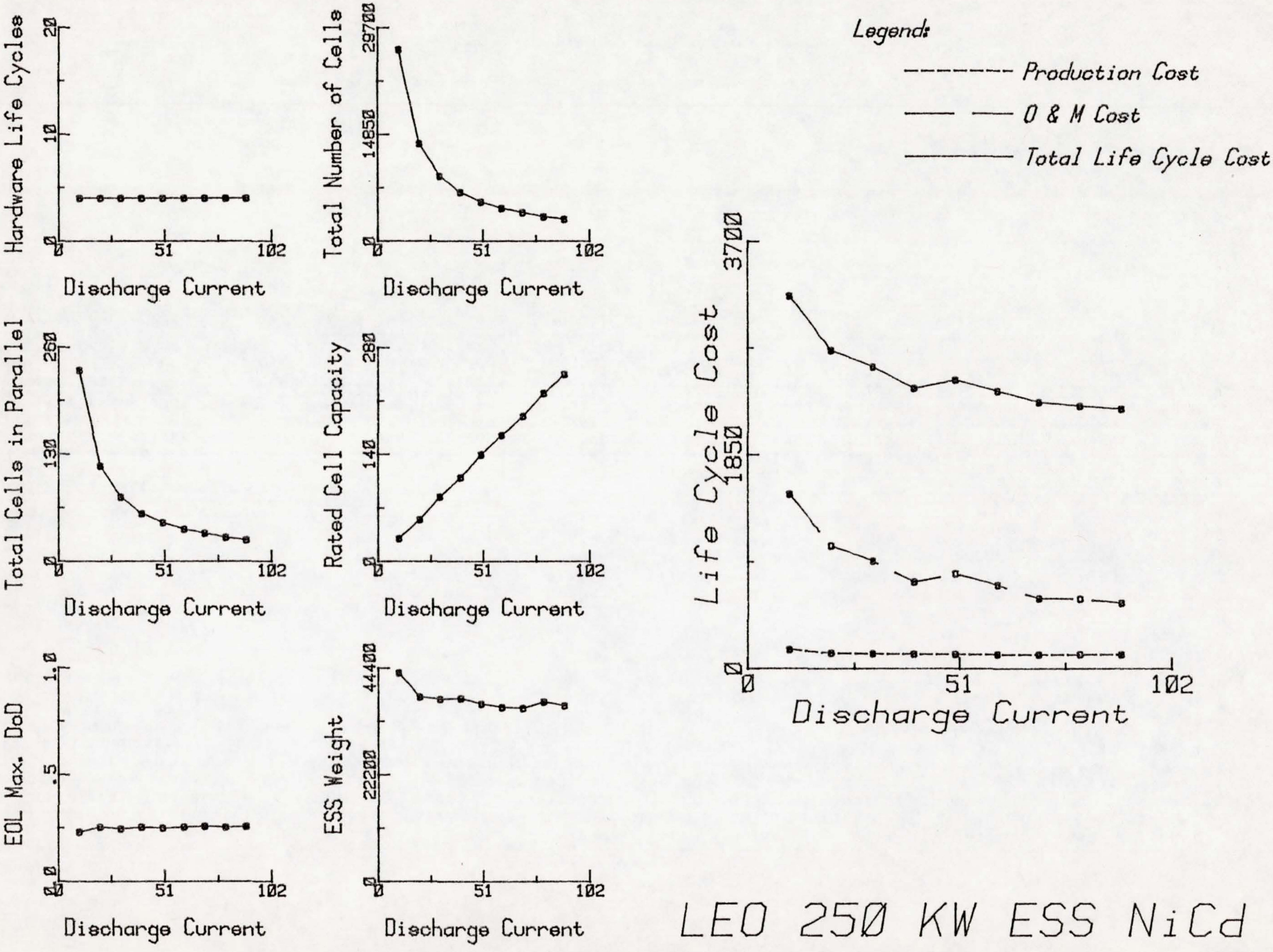

Exhibit 7d. Discharge Current (Capacity Variable) Continued

GEO 25KW ESS (NiCd)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	1	1	1	1	1	1	1	1	1
Maximum Battery Life (Yr)	.647	.647	.647	.647	.647	.647	.647	.647	.647
Rated Cell Capacity (AH)	20	40	60	80	100	120	140	160	180
Maximum Depth of Discharge	.599	.599	.599	.599	.599	.599	.599	.599	.599
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	10.000	20.000	30.000	40.000	50.000	60.000	70.000	80.000	90.000
Minimum Voltage (V)	1.179	1.179	1.179	1.179	1.179	1.179	1.179	1.179	1.179
Recharge Fraction	1.018	1.018	1.018	1.018	1.018	1.018	1.018	1.018	1.018
Charge Current (A)	.529	1.058	1.587	2.116	2.645	3.174	3.703	4.232	4.761
Charge Voltage (V)	1.412	1.412	1.412	1.412	1.412	1.412	1.412	1.412	1.412
Watt-Hour Efficiency	.820	.820	.820	.820	.820	.820	.820	.820	.820
PHYSICAL CHARACTERISTICS									
Total Number of Cells	2640	1320	880	660	550	440	440	440	440
Number of Parallel Batteries	24	12	8	6	5	4	4	4	4
Number of Modules per Battery	6	6	8	8	6	6	8	8	8
Battery Cell Weight (Kg)	.845	1.633	2.422	3.210	3.998	4.786	5.574	6.363	7.151
Battery Cell Volume (Cm^3)	288	578	872	1164	1455	1746	2044	2329	2630
ESS Weight (Kg)	3166	2752	2629	2560	2608	2476	2883	3275	3667
ESS Volume (M^3)	25.611	22.491	15.302	18.937	13.641	11.473	21.098	21.098	21.098
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	10.395	9.098	8.685	8.480	8.468	8.287	8.697	9.093	9.491
Production Cost	52.842	45.500	43.282	42.077	42.684	40.698	46.602	52.303	58.015
Operations & Maintenance Cost	.500	.500	.500	.500	.500	.500	.500	.500	.500
ESS LIFE CYCLE COST	63.737	55.098	52.467	51.057	51.652	49.485	55.799	61.896	68.006
Solar Array Cost	11.111	11.112	11.111	11.112	11.482	11.112	12.576	13.999	15.387
Thermal Control Cost	5.897	5.897	5.897	5.897	5.926	5.897	6.013	6.128	6.245
Power Conditioning Cost	2.961	1.645	1.166	.914	.783	.648	.648	.648	.648
TOTAL LIFE CYCLE COST	83.706	73.752	70.641	68.980	69.843	67.142	75.036	82.671	90.286

Exhibit 7e. Discharge Current (Capacity Variable)

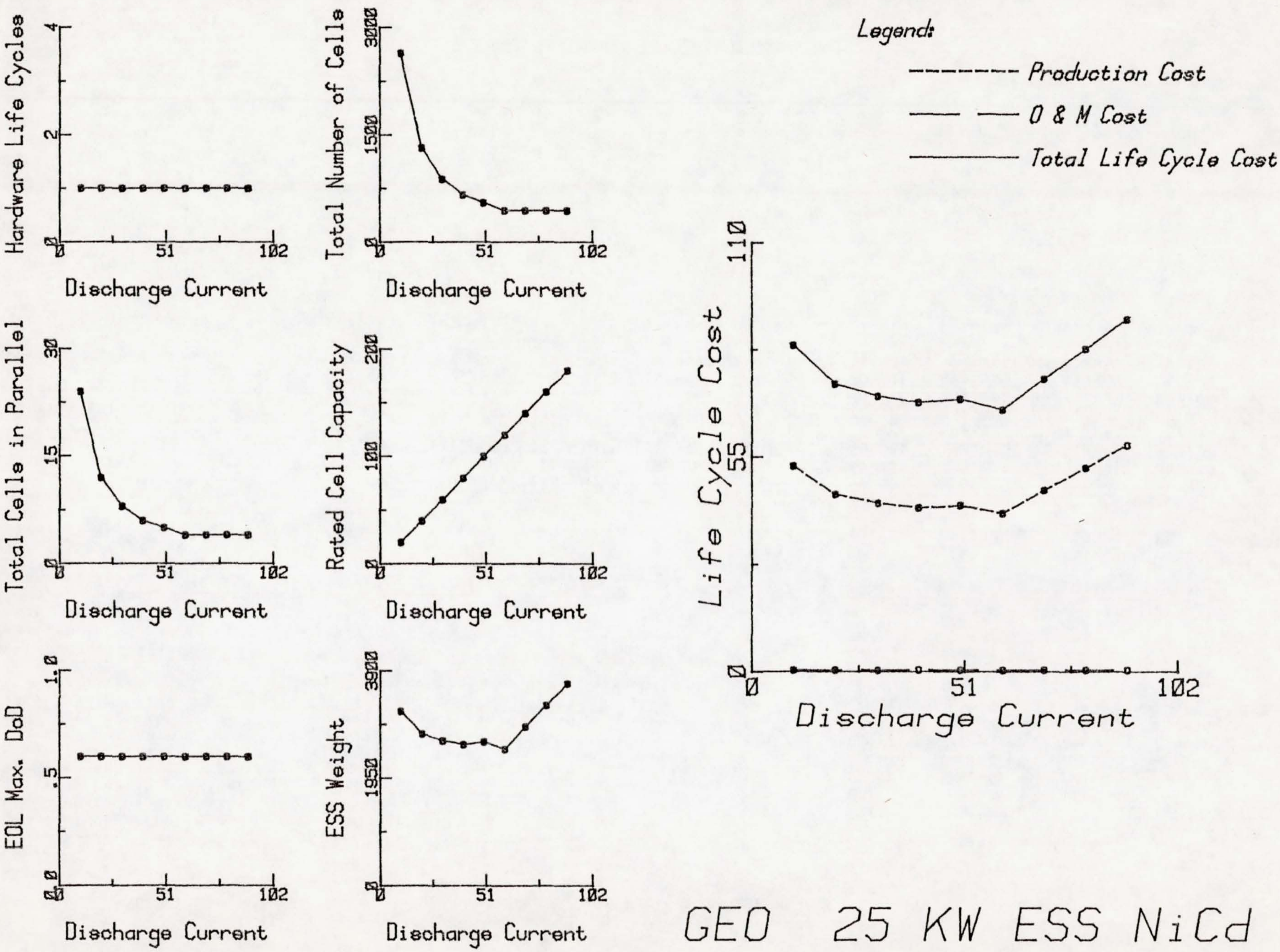

Exhibit 7e. Discharge Current (Capacity Variable) Continued

LEO 25KW ESS (NiCd)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	3	4	5	6	7	8	9	10	11
Maximum Battery Life (Yr)	9.153	7.096	5.963	5.251	4.318	3.832	3.278	3.404	3.500
Rated Cell Capacity (AH)	50	50	50	50	50	50	50	50	50
Maximum Depth of Discharge	.154	.248	.292	.319	.356	.356	.402	.396	.392
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	11.027	17.813	21.051	23.157	25.729	25.729	28.946	28.946	28.946
Minimum Voltage (V)	1.141	1.113	1.105	1.102	1.088	1.090	1.074	1.091	1.104
Recharge Fraction	1.117	1.058	1.038	1.026	1.012	1.012	1.005	1.005	1.005
Charge Current (A)	8.461	12.937	15.000	16.311	17.885	17.885	19.964	19.964	19.964
Charge Voltage (V)	1.639	1.659	1.660	1.657	1.672	1.670	1.688	1.663	1.644
Watt-Hour Efficiency	.623	.635	.641	.648	.643	.645	.633	.653	.668
PHYSICAL CHARACTERISTICS									
Total Number of Cells	2373	1508	1287	1170	1071	1071	960	952	936
Number of Parallel Batteries	21	13	11	10	9	9	8	8	8
Number of Modules per Battery	8	8	6	6	6	6	8	8	8
Battery Cell Weight (Kg)	2.027	2.027	2.027	2.027	2.027	2.027	2.027	2.027	2.027
Battery Cell Volume (Cm^3)	725	725	725	725	725	725	725	725	725
ESS Weight (Kg)	5909	4116	3539	2969	3063	3062	2477	2451	2409
ESS Volume (M^3)	44.412	29.608	22.491	20.580	20.580	20.580	15.302	15.302	15.302
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	13.461	10.905	10.205	9.779	9.535	9.535	9.115	9.087	9.034
Production Cost	25.555	18.688	16.669	15.054	14.888	14.886	13.274	13.188	13.043
Operations & Maintenance Cost	143.405	122.975	109.661	121.291	130.566	149.884	182.015	202.168	221.739
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ESS LIFE CYCLE COST	182.421	152.568	136.535	146.124	154.989	174.305	204.404	224.443	243.816
Solar Array Cost	235.413	232.239	230.486	227.999	230.378	230.086	232.212	227.842	222.700
Thermal Control Cost	7.489	7.204	7.059	6.930	6.955	6.934	6.995	6.789	6.622
Power Conditioning Cost	2.644	1.761	1.528	1.409	1.289	1.289	1.166	1.166	1.166
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TOTAL LIFE CYCLE COST	427.967	393.772	375.608	382.462	393.611	412.614	444.777	460.240	474.304

Exhibit 8a. Hardware Life Cycles (Capacity Fixed)

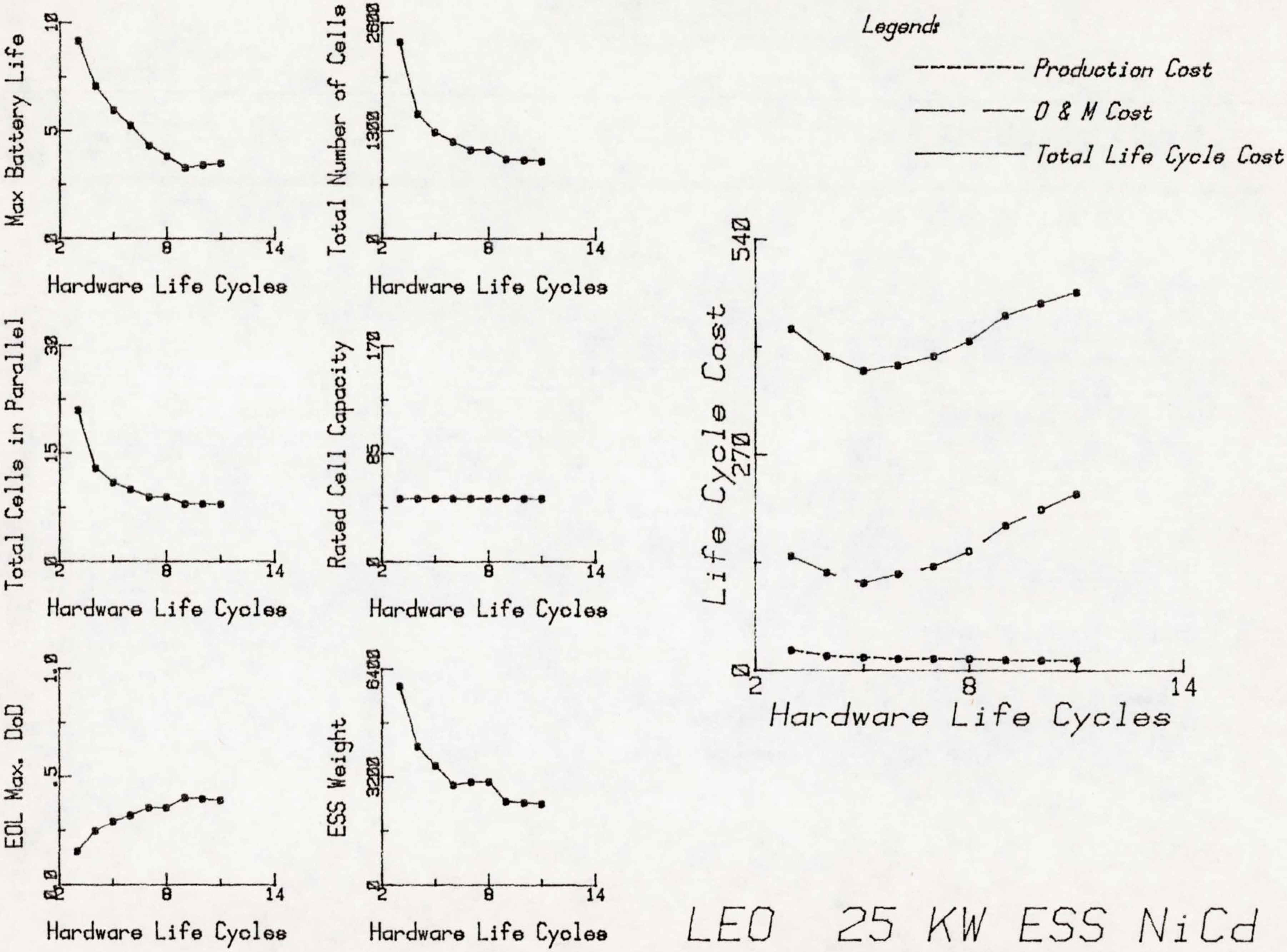

Exhibit 8a. Hardware Life Cycles (Capacity Fixed) Continued

LEO 50KW ESS (NiCd)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	3	4	5	6	7	8	9	10	11
Maximum Battery Life (Yr)	9.153	7.096	5.537	4.714	4.318	3.849	3.278	3.041	2.798
Rated Cell Capacity (AH)	50	50	50	50	50	50	50	50	50
Maximum Depth of Discharge	.154	.248	.308	.340	.356	.377	.402	.427	.427
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	11.027	17.813	22.053	24.375	25.729	27.243	28.946	30.875	30.875
Minimum Voltage (V)	1.141	1.113	1.090	1.085	1.088	1.085	1.074	1.072	1.073
Recharge Fraction	1.117	1.058	1.032	1.019	1.012	1.006	1.005	1.005	1.005
Charge Current (A)	8.461	12.937	15.630	17.056	17.885	18.822	19.964	21.295	21.295
Charge Voltage (V)	1.639	1.659	1.678	1.681	1.672	1.674	1.688	1.690	1.688
Watt-Hour Efficiency	.623	.635	.629	.633	.643	.644	.633	.631	.633
PHYSICAL CHARACTERISTICS									
Total Number of Cells	4746	3016	2499	2261	2142	2023	1920	1815	1800
Number of Parallel Batteries	42	26	21	19	18	17	16	15	15
Number of Modules per Battery	8	8	8	8	8	8	8	8	8
Battery Cell Weight (Kg)	2.027	2.027	2.027	2.027	2.027	2.027	2.027	2.027	2.027
Battery Cell Volume (Cm^3)	725	725	725	725	725	725	725	725	725
ESS Weight (Kg)	11816	8231	6358	6397	5485	5551	4954	4971	4936
ESS Volume (M^3)	88.824	59.216	44.412	44.412	42.160	42.160	30.604	30.604	30.604
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	19.067	14.383	12.877	12.276	11.868	11.572	11.238	10.971	10.930
Production Cost	46.448	32.780	27.010	26.231	23.901	23.606	21.992	21.648	21.522
Operations & Maintenance Cost	282.277	238.986	246.025	269.758	299.655	324.901	346.346	363.226	399.125
ESS LIFE CYCLE COST	347.792	286.149	285.912	308.265	335.424	360.079	379.576	395.845	431.577
Solar Array Cost	410.726	405.188	409.381	405.771	401.941	400.226	405.146	408.203	405.052
Thermal Control Cost	9.776	9.207	9.151	8.961	8.709	8.608	8.789	8.798	8.735
Power Conditioning Cost	4.759	3.169	2.644	2.429	2.320	2.210	2.100	1.988	1.988
TOTAL LIFE CYCLE COST	773.053	703.713	707.088	725.426	748.394	771.123	795.611	814.834	847.352

Exhibit 8b. Hardware Life Cycles (Capacity Fixed)

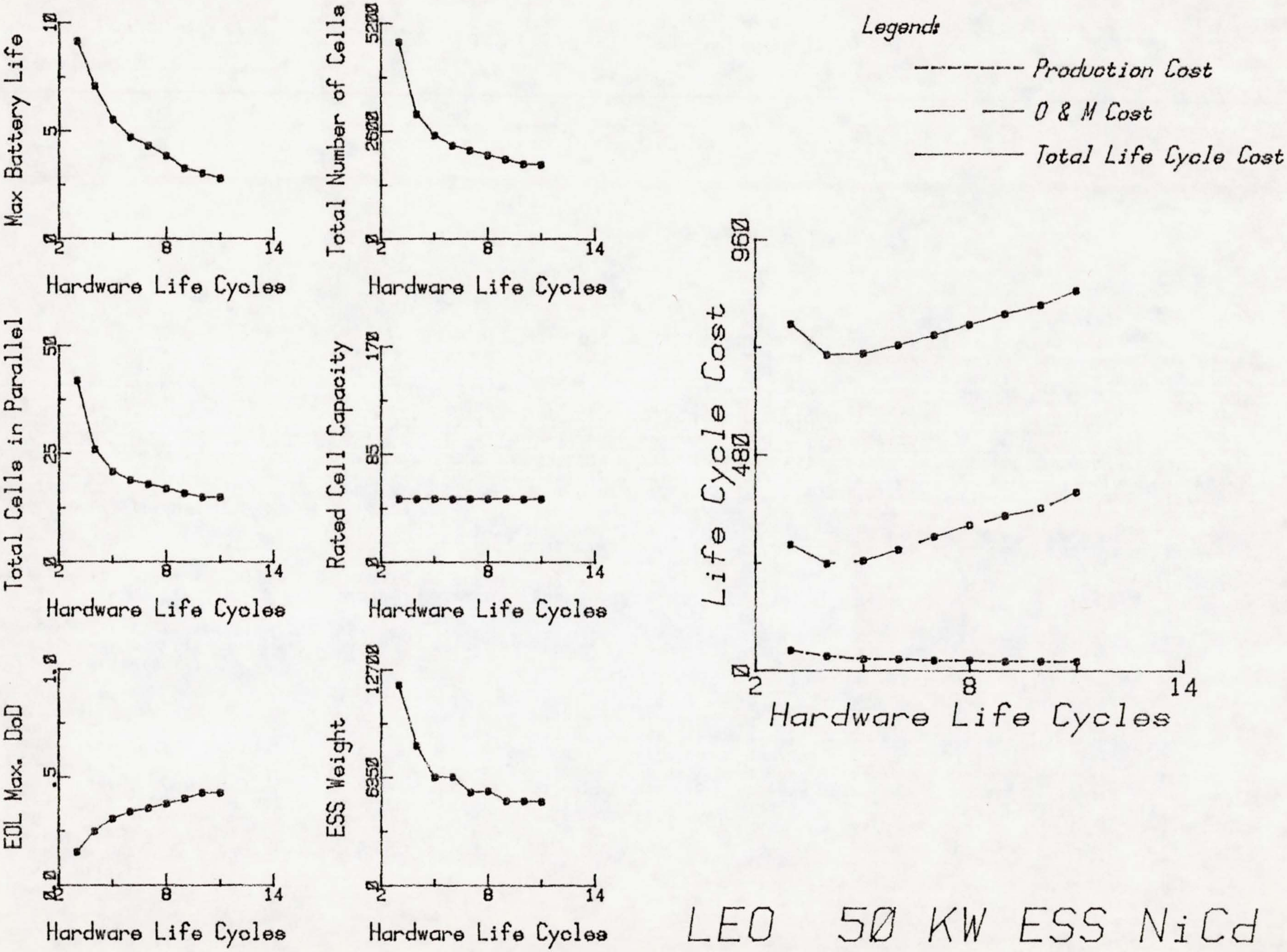

Exhibit 8b. Hardware Life Cycles (Capacity Fixed) Continued

LEO 100KW ESS (NiCd)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	3	4	5	6	7	8	9	10	11
Maximum Battery Life (Yr)	9.153	6.953	5.537	4.714	4.010	3.499	3.278	2.865	2.596
Rated Cell Capacity (AH)	50	50	50	50	50	50	50	50	50
Maximum Depth of Discharge	.154	.254	.308	.340	.369	.392	.402	.416	.430
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	11.027	18.163	22.053	24.375	26.465	28.069	28.946	29.879	30.875
Minimum Voltage (V)	1.141	1.109	1.090	1.085	1.076	1.070	1.074	1.067	1.064
Recharge Fraction	1.117	1.055	1.032	1.019	1.010	1.005	1.005	1.005	1.005
Charge Current (A)	8.461	13.160	15.630	17.056	18.344	19.359	19.964	20.608	21.295
Charge Voltage (V)	1.639	1.664	1.678	1.681	1.689	1.695	1.688	1.698	1.702
Watt-Hour Efficiency	.623	.632	.629	.633	.631	.628	.633	.626	.622
PHYSICAL CHARACTERISTICS									
Total Number of Cells	9492	5967	4998	4522	4200	3993	3840	3751	3660
Number of Parallel Batteries	84	51	42	38	35	33	32	31	30
Number of Modules per Battery	8	8	8	8	8	8	8	8	8
Battery Cell Weight (Kg)	2.027	2.027	2.027	2.027	2.027	2.027	2.027	2.027	2.027
Battery Cell Volume (Cm^3)	725	725	725	725	725	725	725	725	725
ESS Weight (Kg)	24719	16426	12715	12103	10779	10895	9906	9971	10026
ESS Volume (M^3)	168.320	107.110	88.824	76.509	74.020	74.020	61.208	61.208	61.208
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	30.197	21.126	18.530	17.331	16.454	15.957	15.510	15.297	15.080
Production Cost	90.326	60.534	49.345	46.374	42.463	41.964	39.351	39.168	38.959
Operations & Maintenance Cost	559.618	463.056	483.115	527.816	570.693	619.224	675.410	730.124	780.492
ESS LIFE CYCLE COST	680.141	544.716	550.990	591.521	629.610	677.145	730.271	784.589	834.531
Solar Array Cost	716.620	712.325	714.248	707.942	710.032	713.962	706.876	714.780	721.113
Thermal Control Cost	14.350	13.358	13.102	12.721	12.663	12.688	12.378	12.674	12.825
Power Conditioning Cost	8.567	5.611	4.759	4.372	4.078	3.879	3.779	3.679	3.578
TOTAL LIFE CYCLE COST	1419.678	1276.010	1283.099	1316.556	1356.383	1407.674	1453.304	1515.722	1572.047

Exhibit 8c. Hardware Life Cycles (Capacity Fixed)

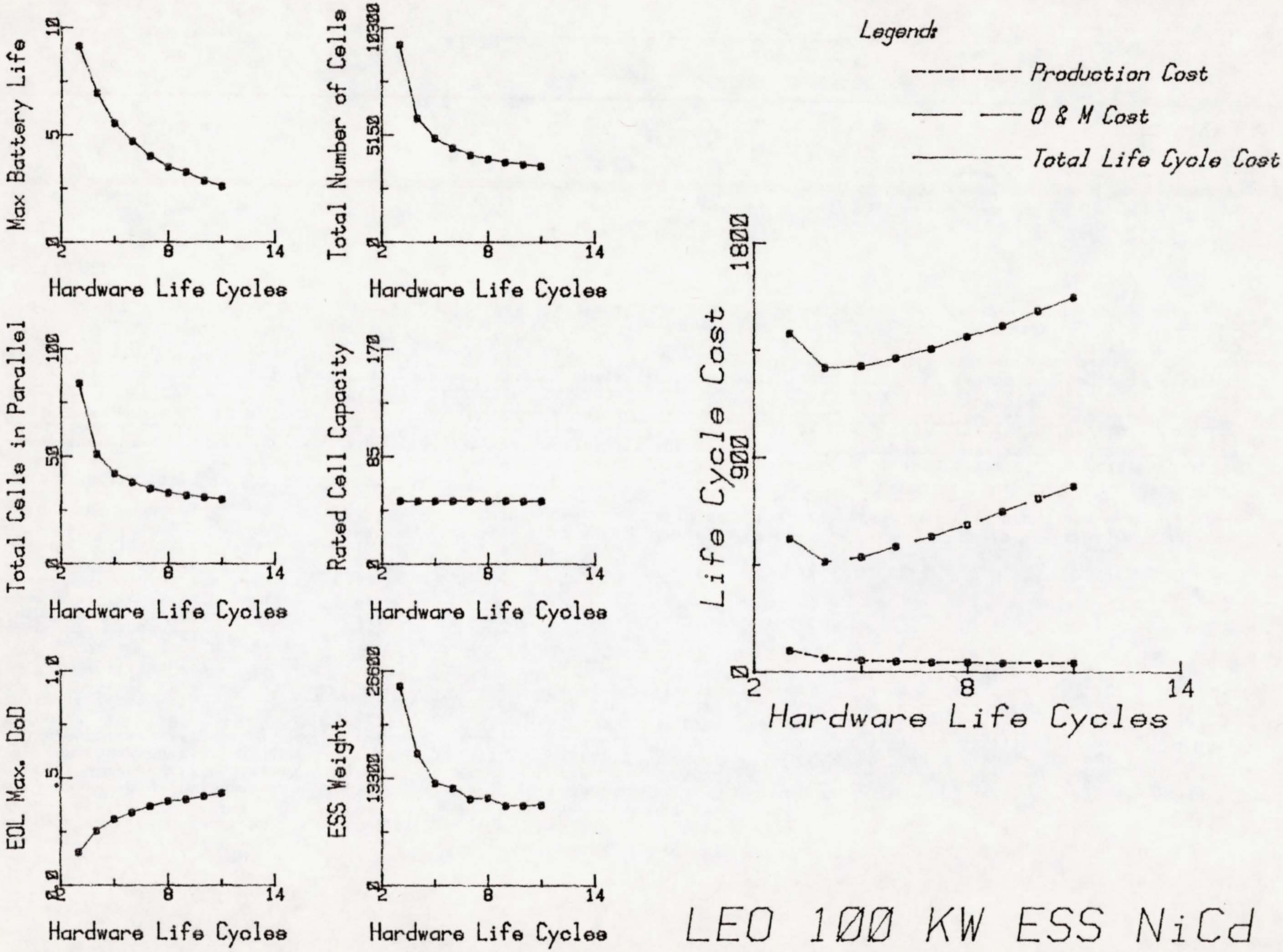

Exhibit 8c. Hardware Life Cycles (Capacity Fixed) Continued

LEO 250KW ESS (NiCd)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	3	4	5	6	7	8	9	10	11
Maximum Battery Life (Yr)	9.147	6.866	5.537	4.594	3.946	3.483	3.128	2.831	2.536
Rated Cell Capacity (AH)	50	50	50	50	50	50	50	50	50
Maximum Depth of Discharge	.155	.257	.308	.345	.372	.395	.409	.425	.443
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	11.080	18.379	22.053	24.635	26.617	28.240	29.312	30.470	31.720
Minimum Voltage (V)	1.141	1.106	1.090	1.080	1.073	1.069	1.067	1.064	1.059
Recharge Fraction	1.117	1.054	1.032	1.018	1.009	1.005	1.005	1.005	1.005
Charge Current (A)	8.494	13.298	15.630	17.213	18.439	19.478	20.217	21.016	21.878
Charge Voltage (V)	1.639	1.667	1.678	1.687	1.693	1.697	1.699	1.702	1.710
Watt-Hour Efficiency	.623	.630	.629	.629	.628	.627	.625	.622	.616
PHYSICAL CHARACTERISTICS									
Total Number of Cells	23617	14742	12495	11280	10440	9922	9559	9272	8906
Number of Parallel Batteries	209	126	105	94	87	82	79	76	73
Number of Modules per Battery	8	8	8	8	8	8	8	8	8
Battery Cell Weight (Kg)	2.027	2.027	2.027	2.027	2.027	2.027	2.027	2.027	2.027
Battery Cell Volume (Cm^3)	725	725	725	725	725	725	725	725	725
ESS Weight (Kg)	60707	37794	33689	29382	27084	27184	24959	25085	25045
ESS Volume (M^3)	413.150	244.830	214.230	183.620	168.320	168.320	153.020	153.020	153.020
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	44.167	29.387	25.689	23.617	22.206	21.389	20.735	20.285	19.702
Production Cost	215.314	136.460	119.995	106.737	98.987	97.366	91.454	90.701	89.322
Operations & Maintenance Cost	1383.294	1132.589	1192.354	1290.232	1397.665	1513.097	1643.753	1763.667	1867.066
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ESS LIFE CYCLE COST	1642.775	1298.436	1338.038	1420.586	1518.858	1631.852	1755.942	1874.653	1976.090
Solar Array Cost	1494.830	1487.352	1490.734	1490.187	1483.934	1491.314	1492.851	1505.298	1510.849
Thermal Control Cost	28.035	25.715	24.955	24.485	24.079	24.024	24.055	24.335	24.779
Power Conditioning Cost	18.557	12.082	10.351	9.424	8.826	8.394	8.132	7.870	7.606
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TOTAL LIFE CYCLE COST	3184.197	2823.585	2864.078	2944.682	3035.697	3155.584	3280.980	3412.156	3519.324

Exhibit 8d. Hardware Life Cycles (Capacity Fixed)

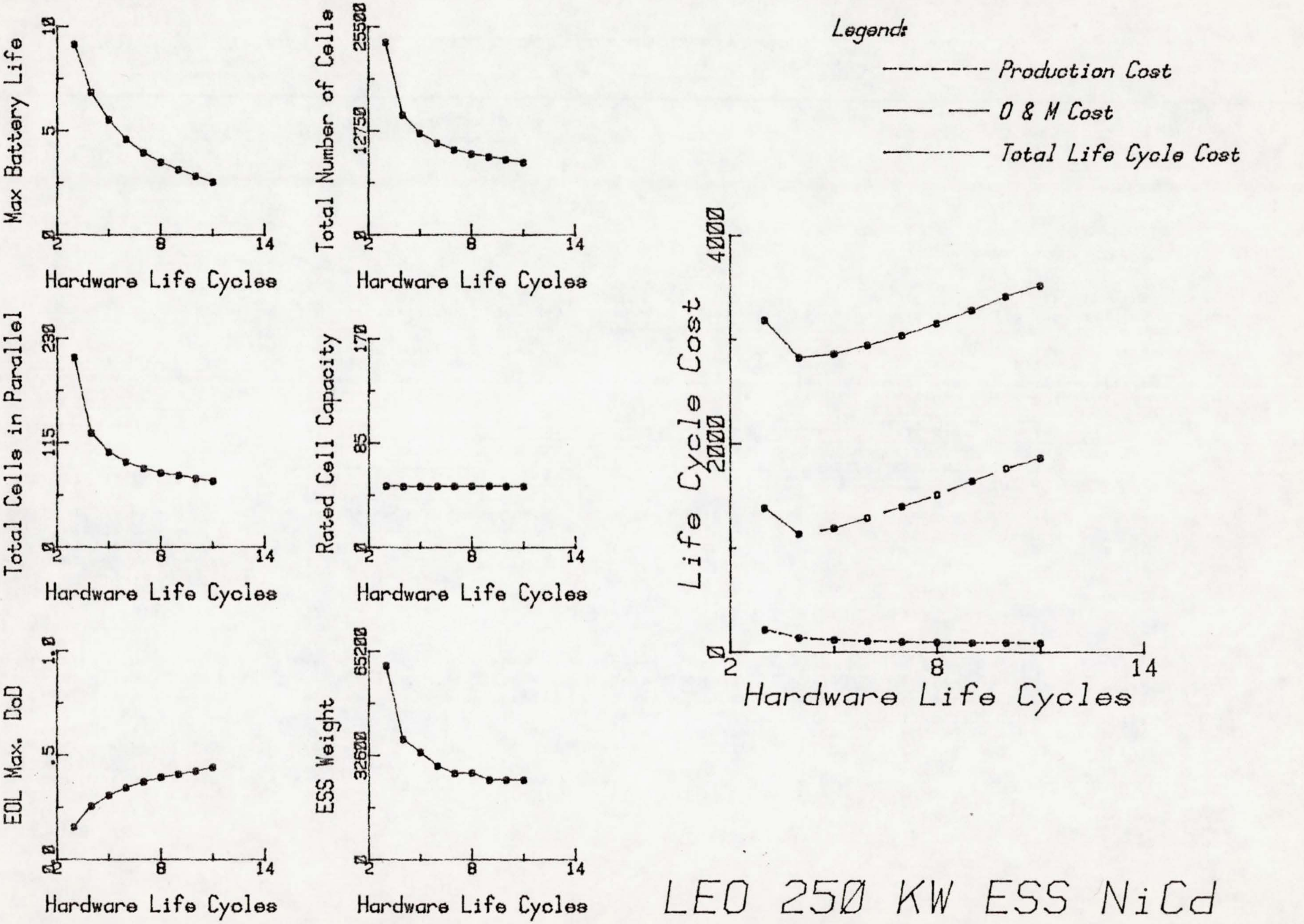

Exhibit 8d. Hardware Life Cycles (Capacity Fixed) Continued

LEO 25KW ESS (NIH2)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	3	3	4	5	6	8	12	20	40
Maximum Battery Life (Yr)	11.091	9.428	7.778	6.154	4.742	3.498	2.394	1.433	.690
Rated Cell Capacity (AH)	55	45	35	30	25	25	20	20	20
Maximum Depth of Discharge	.250	.325	.400	.475	.550	.625	.700	.775	.850
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	20.049	20.969	20.278	20.618	19.728	22.377	20.108	22.257	24.310
Minimum Voltage (V)	1.211	1.157	1.150	1.130	1.102	1.081	1.071	1.057	1.031
Recharge Fraction	1.071	1.071	1.072	1.072	1.072	1.077	1.085	1.094	1.114
Charge Current (A)	14.750	15.426	14.919	15.169	14.514	16.552	14.981	16.725	17.784
Charge Voltage (V)	1.662	1.695	1.683	1.690	1.710	1.719	1.720	1.729	1.746
Watt-Hour Efficiency	.680	.637	.638	.624	.601	.584	.573	.559	.530
PHYSICAL CHARACTERISTICS									
Total Number of Cells	1284	1344	1356	1380	1404	1440	1452	1464	1500
Number of Parallel Batteries	12	12	12	12	12	12	12	12	12
Number of Modules per Battery	4	4	5	5	5	5	5	5	5
Battery Cell Weight (Kg)	1.247	1.021	.794	.680	.567	.567	.454	.454	.454
Battery Cell Volume (Cm^3)	3461	1936	1772	1695	1620	1620	1547	1547	1547
ESS Weight (Kg)	3165	2846	2400	2201	1974	2065	1783	1840	1919
ESS Volume (M^3)	38.596	18.964	28.446	28.446	28.446	28.446	28.446	28.446	31.607
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	10.440	10.121	9.628	9.413	9.173	9.281	8.982	9.030	9.126
Production Cost	18.017	15.302	14.964	14.721	14.456	14.579	14.254	14.302	15.063
Operations & Maintenance Cost	54.131	49.822	77.363	96.807	115.636	155.612	231.814	388.189	795.468
ESS LIFE CYCLE COST	82.588	75.245	101.955	120.941	139.265	179.472	255.050	411.521	819.657
Solar Array Cost	227.154	248.176	241.938	249.500	246.425	280.683	261.005	288.113	311.202
Thermal Control Cost	7.064	7.494	7.327	7.440	7.519	8.010	7.797	8.227	8.763
Power Conditioning Cost	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645
TOTAL LIFE CYCLE COST	318.451	332.560	352.865	379.526	394.854	469.810	525.497	709.506	1141.267

Exhibit 9a. Depth of Discharge (Capacity Variable)

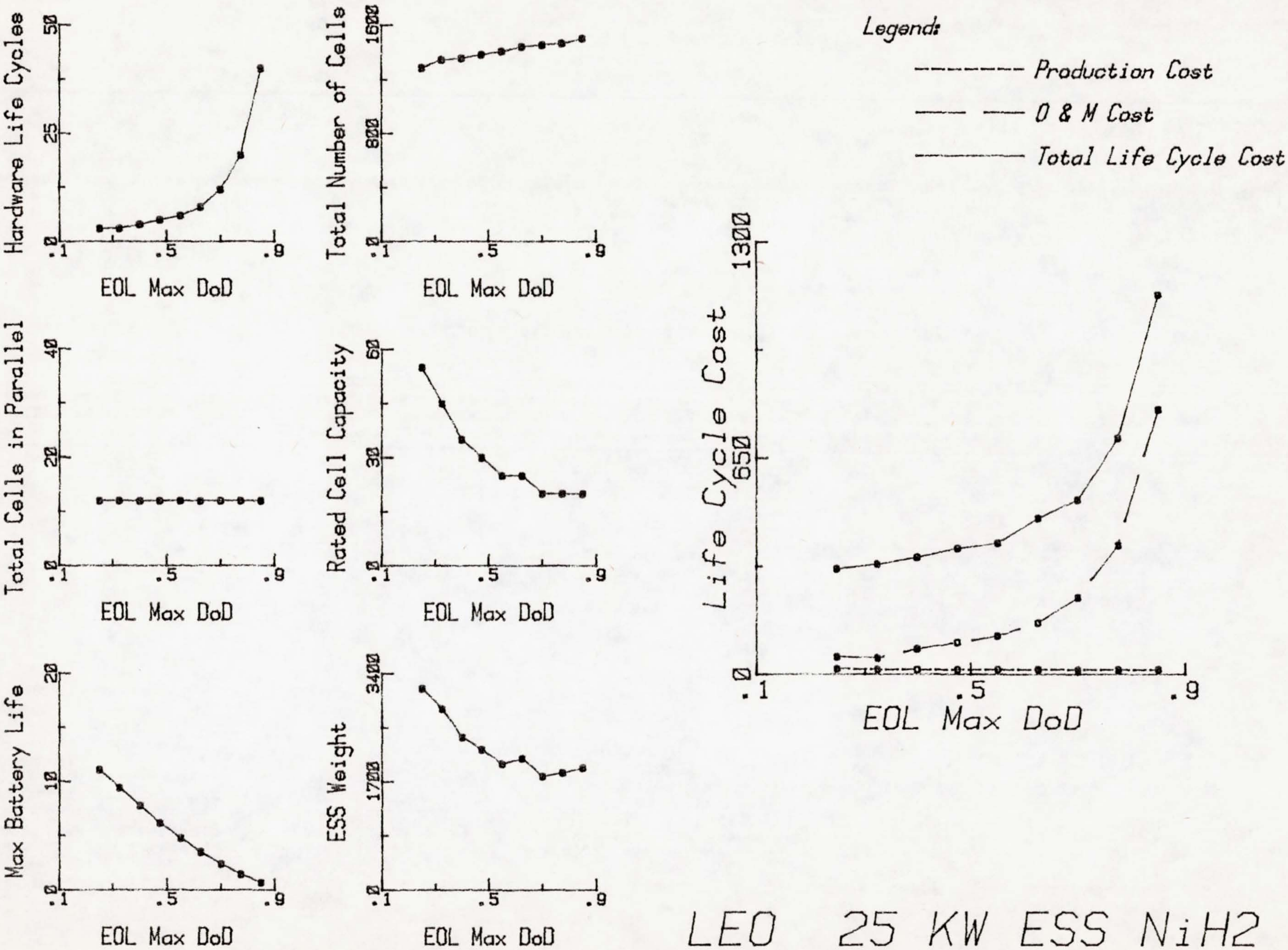

Exhibit 9a. Depth of Discharge (Capacity Variable) Continued

LEO 50KW ESS (NIH2)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	3	3	4	5	6	8	12	20	40
Maximum Battery Life (Yr)	11.091	9.428	7.778	6.154	4.742	3.498	2.394	1.433	.690
Rated Cell Capacity (AH)	110	85	70	60	50	45	40	35	35
Maximum Depth of Discharge	.250	.325	.400	.475	.550	.625	.700	.775	.850
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	40.097	39.609	40.557	41.235	39.455	40.278	40.215	38.950	42.541
Minimum Voltage (V)	1.211	1.157	1.150	1.130	1.102	1.081	1.071	1.057	1.031
Recharge Fraction	1.071	1.071	1.072	1.072	1.072	1.077	1.085	1.094	1.114
Charge Current (A)	29.497	29.138	29.838	30.337	29.028	29.793	29.962	29.268	31.119
Charge Voltage (V)	1.662	1.695	1.683	1.690	1.710	1.719	1.720	1.729	1.746
Watt-Hour Efficiency	.680	.637	.638	.624	.601	.584	.573	.559	.530
PHYSICAL CHARACTERISTICS									
Total Number of Cells	1284	1344	1356	1380	1404	1440	1452	1464	1500
Number of Parallel Batteries	12	12	12	12	12	12	12	12	12
Number of Modules per Battery	4	4	5	5	5	5	5	5	5
Battery Cell Weight (Kg)	2.495	1.928	1.588	1.361	1.134	1.021	.907	.794	.794
Battery Cell Volume (Cm^3)	4128	3825	3642	3521	2020	1936	1853	1772	1772
ESS Weight (Kg)	5953	5040	4422	4022	3568	3412	3185	2935	3071
ESS Volume (M^3)	38.596	48.753	42.660	44.692	28.446	28.446	28.446	28.446	31.607
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	12.212	11.341	10.708	10.311	9.876	9.728	9.500	9.256	9.375
Production Cost	25.287	22.385	20.280	20.181	17.450	16.952	16.207	15.463	16.265
Operations & Maintenance Cost	64.052	59.621	87.894	111.361	125.119	165.861	245.343	401.966	824.833
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ESS LIFE CYCLE COST	101.551	93.347	118.882	141.853	152.445	192.541	271.050	426.685	850.473
Solar Array Cost	396.279	413.577	422.115	435.300	429.948	449.975	455.387	451.564	487.713
Thermal Control Cost	8.927	9.534	9.452	9.680	9.837	10.258	10.394	10.498	11.433
Power Conditioning Cost	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645
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TOTAL LIFE CYCLE COST	508.402	518.103	552.094	588.478	593.875	654.419	738.476	890.392	1351.264

Exhibit 9b. Depth of Discharge (Capacity Variable)

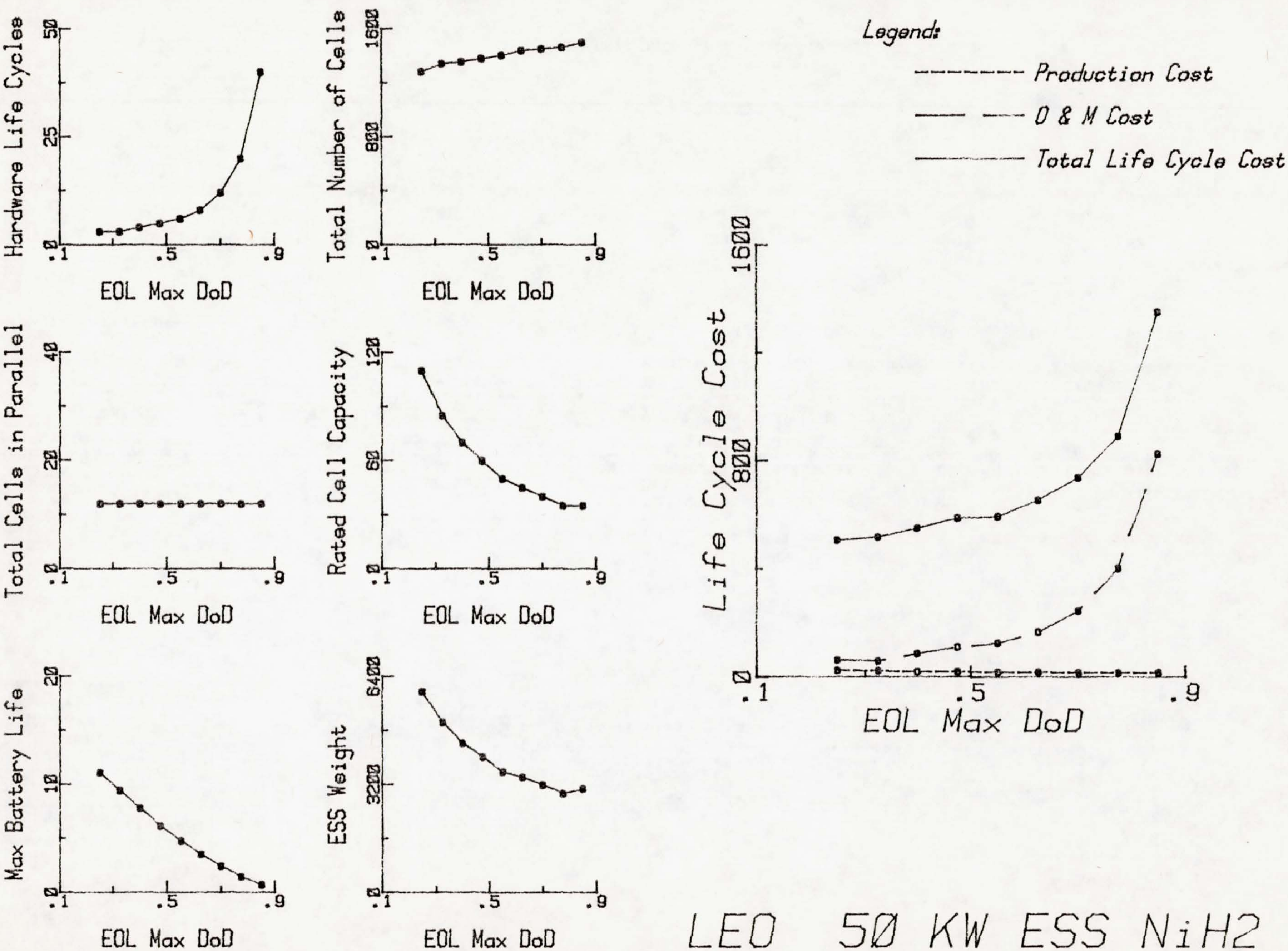

Exhibit 9b. Depth of Discharge (Capacity Variable) Continued

LEO 100KW ESS (NiH_2)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	3	3	4	5	6	8	12	20	40
Maximum Battery Life (Yr)	11.091	9.428	7.778	6.154	4.742	3.498	2.394	1.433	.690
Rated Cell Capacity (AH)	215	170	135	115	100	90	80	70	65
Maximum Depth of Discharge	.250	.325	.400	.475	.550	.625	.700	.775	.850
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	78.371	79.216	78.216	79.032	78.910	80.554	80.430	77.900	79.003
Minimum Voltage (V)	1.211	1.157	1.150	1.130	1.102	1.081	1.071	1.057	1.031
Recharge Fraction	1.071	1.071	1.072	1.072	1.072	1.077	1.085	1.094	1.114
Charge Current (A)	57.653	58.275	57.545	58.145	58.055	59.585	59.924	58.538	57.794
Charge Voltage (V)	1.662	1.695	1.683	1.690	1.710	1.719	1.720	1.729	1.746
Watt-Hour Efficiency	.680	.637	.638	.624	.601	.584	.573	.559	.530
PHYSICAL CHARACTERISTICS									
Total Number of Cells	1284	1344	1356	1380	1404	1440	1452	1464	1500
Number of Parallel Batteries	12	12	12	12	12	12	12	12	12
Number of Modules per Battery	4	4	5	5	5	5	5	5	5
Battery Cell Weight (Kg)	4.876	3.856	3.062	2.608	2.268	2.041	1.814	1.588	1.474
Battery Cell Volume (Cm^3)	5404	4857	4432	4189	4007	3886	3764	3642	3582
ESS Weight (Kg)	11276	9701	8176	7361	6756	6443	5988	5488	5375
ESS Volume (M^3)	38.596	48.753	42.660	44.692	44.692	44.692	44.692	44.692	44.692
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	15.758	14.304	12.899	12.143	11.580	11.279	10.855	10.409	10.296
Production Cost	42.427	37.176	32.106	29.394	27.380	26.329	24.817	23.189	22.804
Operations & Maintenance Cost	88.178	80.031	111.612	134.955	156.840	206.899	303.283	489.868	974.074
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ESS LIFE CYCLE COST	146.363	131.511	156.617	176.492	195.800	244.507	338.955	523.466	1007.174
Solar Array Cost	678.727	721.561	715.271	733.940	750.150	785.035	794.493	787.871	801.778
Thermal Control Cost	12.484	13.866	13.400	13.786	14.475	15.311	15.587	15.793	16.778
Power Conditioning Cost	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645
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TOTAL LIFE CYCLE COST	839.219	868.583	886.933	925.863	962.070	1046.498	1150.680	1328.775	1827.375

Exhibit 9c. Depth of Discharge (Capacity Variable)

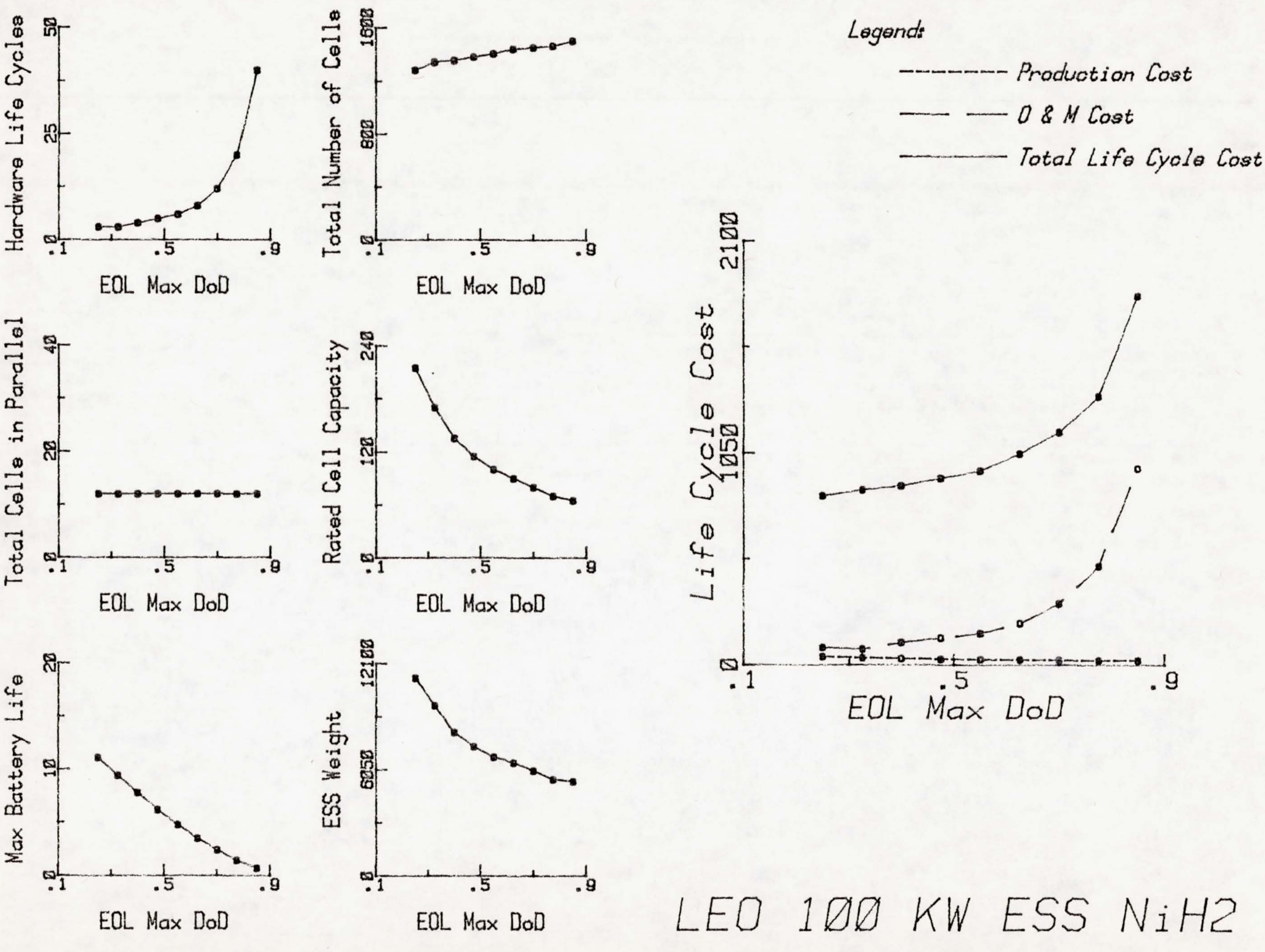

Exhibit 9c. Depth of Discharge (Capacity Variable) Continued

LEO 250KW ESS (NIH2)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	3	3	4	5	6	8	12	20	40
Maximum Battery Life (Yr)	11.091	9.428	7.778	6.154	4.742	3.498	2.394	1.433	.690
Rated Cell Capacity (AH)	265	210	170	145	125	110	100	90	80
Maximum Depth of Discharge	.250	.325	.400	.475	.550	.625	.700	.775	.850
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	96.597	97.856	98.495	99.649	98.637	98.455	100.540	100.160	97.234
Minimum Voltage (V)	1.211	1.157	1.150	1.130	1.102	1.081	1.071	1.057	1.031
Recharge Fraction	1.071	1.071	1.072	1.072	1.072	1.077	1.085	1.094	1.114
Charge Current (A)	71.061	71.987	72.465	73.313	72.568	72.827	74.908	75.264	71.131
Charge Voltage (V)	1.662	1.695	1.683	1.690	1.710	1.719	1.720	1.729	1.746
Watt-Hour Efficiency	.680	.637	.637	.624	.601	.584	.573	.559	.530
PHYSICAL CHARACTERISTICS									
Total Number of Cells	2568	2688	2712	2760	2808	2880	2904	2928	3000
Number of Parallel Batteries	24	24	24	24	24	24	24	24	24
Number of Modules per Battery	4	4	5	5	5	5	5	5	5
Battery Cell Weight (Kg)	6.010	4.763	3.856	3.289	2.835	2.495	2.268	2.041	1.814
Battery Cell Volume (Cm^3)	6011	5343	4857	4553	4310	4128	4007	3886	3764
ESS Weight (Kg)	27619	23787	20394	18365	16700	15580	14779	13894	13055
ESS Volume (M^3)	77.191	97.506	85.319	89.383	89.383	89.383	89.383	89.383	89.383
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	20.364	18.104	16.100	14.903	13.930	13.283	12.777	12.246	11.794
Production Cost	95.953	83.235	71.979	65.259	59.773	56.101	53.381	50.440	47.771
Operations & Maintenance Cost	193.512	173.824	240.974	289.540	332.914	433.110	638.037	1035.899	2016.624
ESS LIFE CYCLE COST	309.829	275.163	329.053	369.702	406.617	502.494	704.195	1098.585	2076.189
Solar Array Cost	1400.686	1491.724	1501.822	1542.559	1565.579	1609.295	1658.313	1681.959	1652.688
Thermal Control Cost	23.155	26.610	25.855	26.855	28.380	29.925	31.170	32.440	33.695
Power Conditioning Cost	2.961	2.961	2.961	2.961	2.961	2.961	2.961	2.961	2.961
TOTAL LIFE CYCLE COST	1736.631	1796.458	1859.691	1942.077	2003.537	2144.675	2396.639	2815.945	3765.533

Exhibit 9d. Depth of Discharge (Capacity Variable)

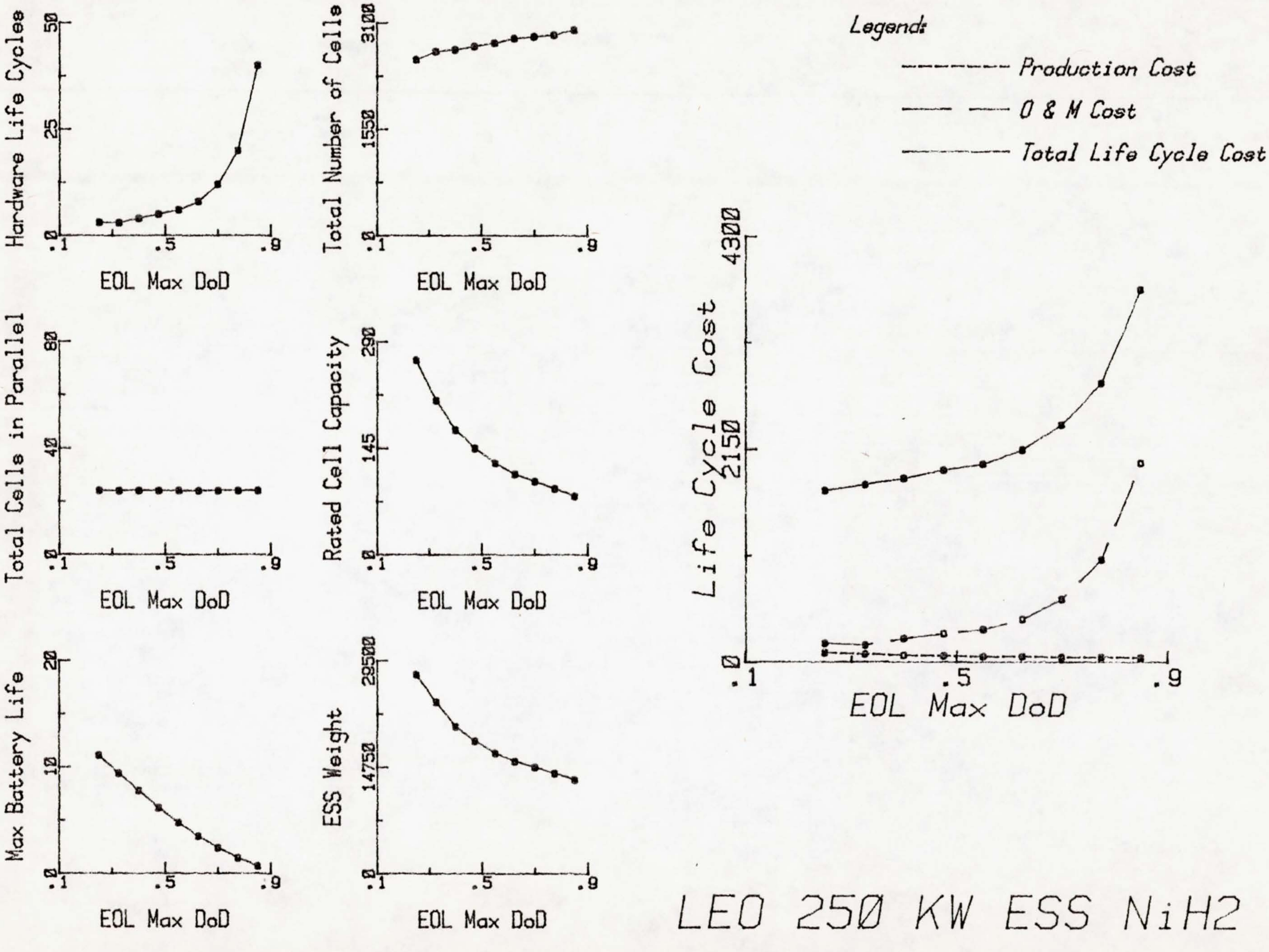

Exhibit 9d. Depth of Discharge (Capacity Variable) Continued

GEO 25KW ESS (NIH2)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	1	1	1	1	1	1	1	1	1
Maximum Battery Life (Yr)	11.091	9.428	7.778	6.154	4.742	3.498	2.394	1.433	.690
Rated Cell Capacity (AH)	95	75	60	50	45	45	40	35	35
Maximum Depth of Discharge	.250	.325	.400	.475	.550	.625	.700	.775	.850
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	20.089	20.616	20.294	20.078	20.914	23.750	23.618	22.824	24.870
Minimum Voltage (V)	1.386	1.360	1.332	1.303	1.275	1.252	1.235	1.216	1.188
Recharge Fraction	1.071	1.071	1.072	1.072	1.072	1.094	1.157	1.327	1.577
Charge Current (A)	1.119	1.148	1.130	1.119	1.165	1.351	1.420	1.574	2.730
Charge Voltage (V)	1.463	1.464	1.466	1.468	1.470	1.473	1.478	1.488	1.509
Watt-Hour Efficiency	.884	.867	.848	.828	.809	.776	.722	.616	.373
PHYSICAL CHARACTERISTICS									
Total Number of Cells	1116	1140	1164	1188	1224	1236	1260	1272	1308
Number of Parallel Batteries	12	12	12	12	12	12	12	12	12
Number of Modules per Battery	4	4	4	4	4	4	4	4	4
Battery Cell Weight (Kg)	2.155	1.701	1.361	1.134	1.021	1.021	.907	.794	.794
Battery Cell Volume (Cm^3)	3946	3703	3521	2020	1936	1936	1853	1772	1772
ESS Weight (Kg)	4313	3613	3070	2710	2577	2639	2460	2247	2325
ESS Volume (M^3)	36.566	36.566	36.566	17.384	17.384	17.384	12.643	15.803	12.643
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	10.853	10.161	9.628	9.271	9.155	9.206	9.036	8.821	8.920
Production Cost	68.512	59.933	56.469	45.216	43.313	44.194	41.615	38.534	39.693
Operations & Maintenance Cost	.500	.500	.500	.500	.500	.500	.500	.500	.500
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ESS LIFE CYCLE COST	79.865	70.594	66.597	54.987	52.968	53.900	51.151	47.855	49.113
Solar Array Cost	10.450	10.863	10.917	11.016	11.672	13.272	14.068	15.476	24.904
Thermal Control Cost	5.362	5.437	5.515	5.594	5.705	5.853	5.914	5.945	6.105
Power Conditioning Cost	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645
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TOTAL LIFE CYCLE COST	97.322	88.539	84.674	73.242	71.990	74.670	72.778	70.921	81.767

Exhibit 9e. Depth of Discharge (Capacity Variable)

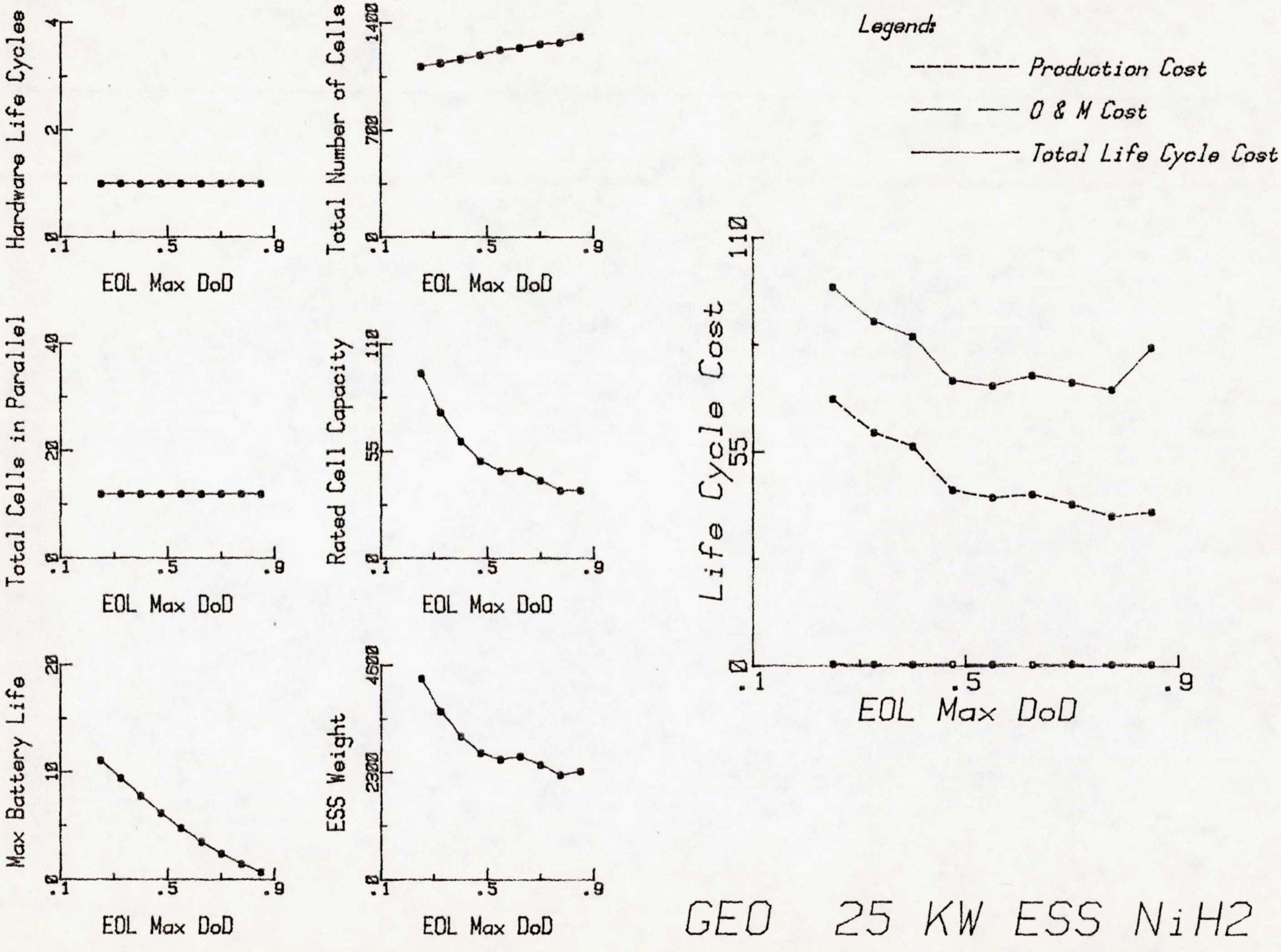

Exhibit 9e. Depth of Discharge (Capacity Variable) Continued

LEO 25KW ESS (NiH2)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	10	7	5	5	4	3	3	3	3
Maximum Battery Life (Yr)	3.000	4.250	5.500	6.750	8.000	9.250	10.500	11.750	13.000
Rated Cell Capacity (AH)	25	25	30	30	35	45	50	60	85
Maximum Depth of Discharge	.657	.577	.508	.447	.390	.333	.277	.220	.162
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	19.298	19.298	19.298	19.298	19.298	19.298	19.298	19.298	19.298
Minimum Voltage (V)	1.097	1.106	1.115	1.148	1.157	1.160	1.196	1.233	1.277
Recharge Fraction	1.080	1.073	1.072	1.071	1.071	1.072	1.072	1.072	1.072
Charge Current (A)	14.312	14.219	14.198	14.197	14.197	14.198	14.198	14.198	14.198
Charge Voltage (V)	1.701	1.701	1.710	1.673	1.677	1.697	1.672	1.651	1.631
Watt-Hour Efficiency	.597	.606	.609	.641	.644	.638	.668	.697	.731
PHYSICAL CHARACTERISTICS									
Total Number of Cells	1416	1404	1392	1356	1344	1344	1296	1260	1212
Number of Parallel Batteries	12	12	12	12	12	12	12	12	12
Number of Modules per Battery	5	5	5	5	4	4	4	4	4
Battery Cell Weight (Kg)	.567	.567	.680	.680	.794	1.021	1.134	1.361	1.928
Battery Cell Volume (Cm^3)	1620	1620	1695	1695	1772	1936	2020	3521	3825
ESS Weight (Kg)	1977	1963	2196	2143	2344	2817	2955	3320	4260
ESS Volume (M^3)	28.446	28.446	28.446	28.446	18.964	18.964	18.964	34.534	34.534
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	9.195	9.168	9.431	9.341	9.572	10.107	10.221	10.600	11.588
Production Cost	14.486	14.454	14.747	14.640	13.666	15.232	15.635	17.367	19.890
Operations & Maintenance Cost	195.650	135.638	96.988	96.726	64.685	49.794	50.420	53.110	56.876
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ESS LIFE CYCLE COST	219.331	159.260	121.166	120.707	87.923	75.133	76.276	81.077	88.354
Solar Array Cost	244.303	241.404	240.453	231.311	230.156	232.427	223.022	215.853	207.157
Thermal Control Cost	7.477	7.414	7.470	7.134	7.163	7.334	7.082	6.890	6.704
Power Conditioning Cost	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645
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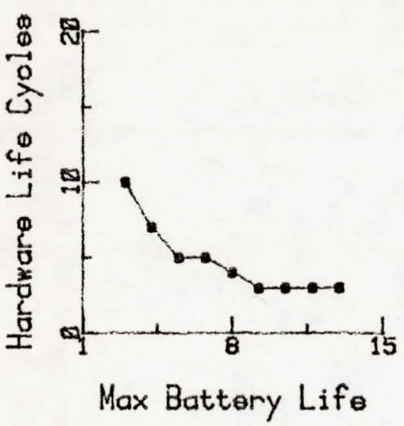
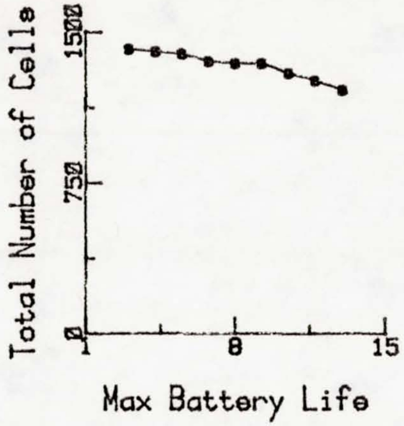
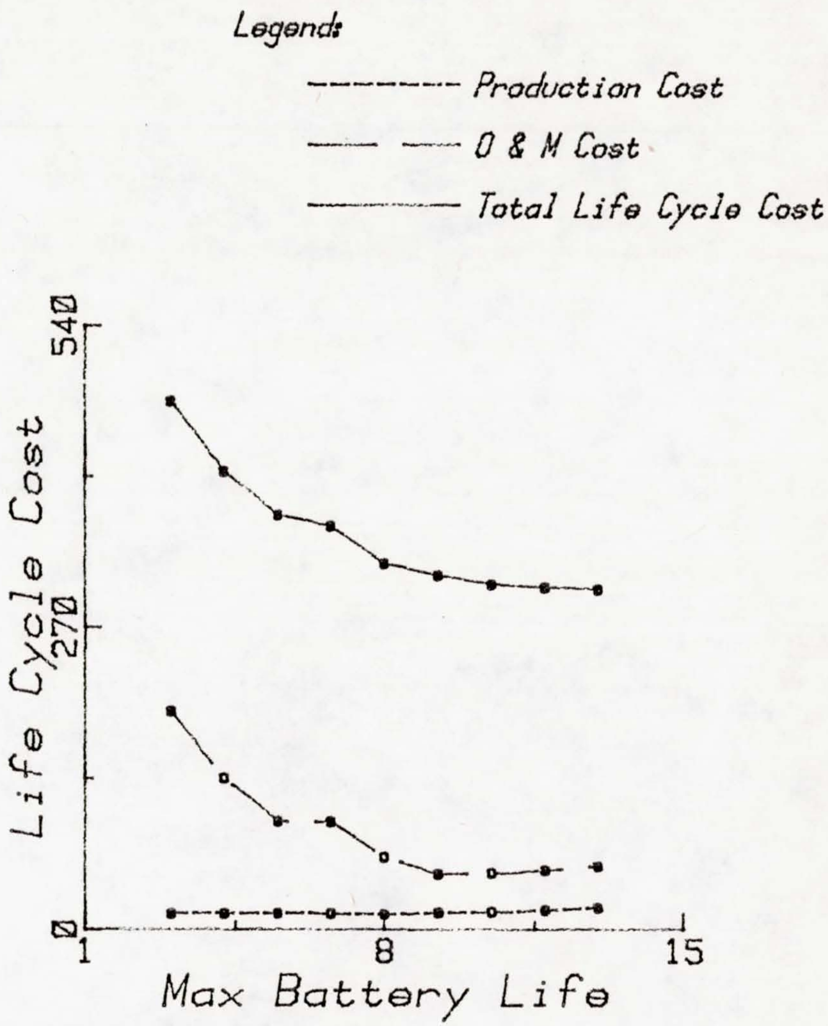
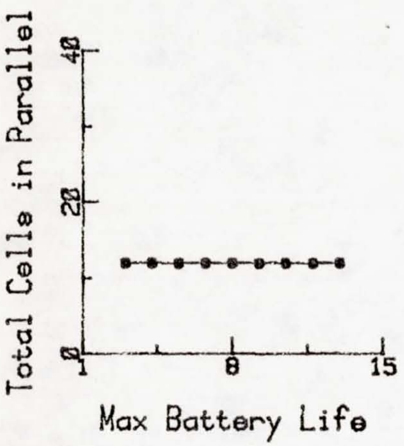
TOTAL LIFE CYCLE COST	472.756	409.723	370.734	360.797	326.887	316.539	308.025	305.465	303.860

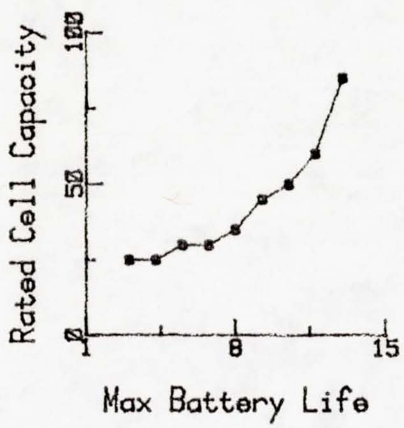
Exhibit 10a. Cell Life (Capacity Variable)

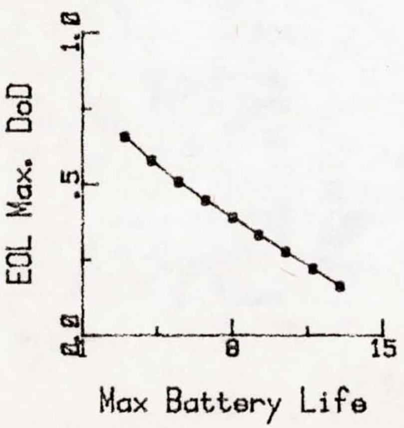


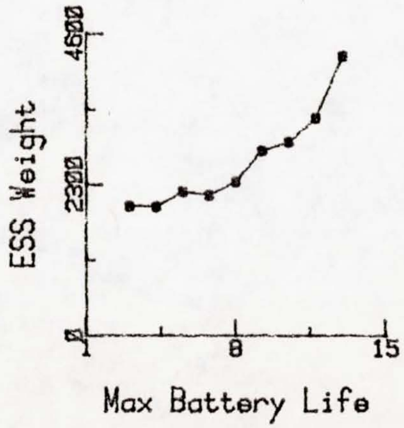












LEO 25 KW ESS NiH2

Exhibit 10a. Cell Life (Capacity Variable) Continued

LEO 50KW ESS (NiH2)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	10	7	5	5	4	3	3	3	3
Maximum Battery Life (Yr)	3.000	4.250	5.500	6.750	8.000	9.250	10.500	11.750	13.000
Rated Cell Capacity (AH)	45	50	55	60	70	85	100	120	165
Maximum Depth of Discharge	.657	.577	.508	.447	.390	.333	.277	.220	.162
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	38.594	38.594	38.594	38.594	38.594	38.594	38.594	38.594	38.594
Minimum Voltage (V)	1.089	1.106	1.110	1.148	1.157	1.154	1.196	1.233	1.275
Recharge Fraction	1.080	1.073	1.072	1.071	1.071	1.072	1.072	1.072	1.072
Charge Current (A)	28.622	28.436	28.394	28.391	28.391	28.394	28.394	28.394	28.394
Charge Voltage (V)	1.704	1.701	1.712	1.673	1.677	1.698	1.672	1.651	1.632
Watt-Hour Efficiency	.592	.606	.605	.641	.644	.634	.667	.697	.729
PHYSICAL CHARACTERISTICS									
Total Number of Cells	1428	1404	1404	1356	1344	1344	1296	1260	1224
Number of Parallel Batteries	12	12	12	12	12	12	12	12	12
Number of Modules per Battery	5	5	5	5	4	4	4	4	4
Battery Cell Weight (Kg)	1.021	1.134	1.247	1.361	1.588	1.928	2.268	2.722	3.742
Battery Cell Volume (Cm^3)	1936	2020	3461	3521	3642	3825	4007	4250	4796
ESS Weight (Kg)	3350	3547	3798	3908	4310	5024	5532	6263	8005
ESS Volume (M^3)	28.446	28.446	44.692	42.660	48.753	48.753	40.628	34.534	36.566
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	9.681	9.868	10.122	10.213	10.624	11.334	11.816	12.521	14.218
Production Cost	16.771	17.400	19.939	19.634	21.435	22.377	23.918	26.322	32.104
Operations & Maintenance Cost	207.929	146.844	110.742	110.094	80.835	59.657	62.032	65.708	74.478
ESS LIFE CYCLE COST	234.381	174.112	140.803	139.941	112.894	93.368	97.766	104.551	120.800
Solar Array Cost	429.883	421.165	422.924	403.546	401.526	405.686	389.088	376.580	364.437
Thermal Control Cost	9.827	9.626	9.802	9.066	9.125	9.475	8.962	8.580	8.244
Power Conditioning Cost	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645
TOTAL LIFE CYCLE COST	675.736	606.548	575.174	554.198	525.190	510.174	497.461	491.356	495.126

Exhibit 10b. Cell Life (Capacity Variable)

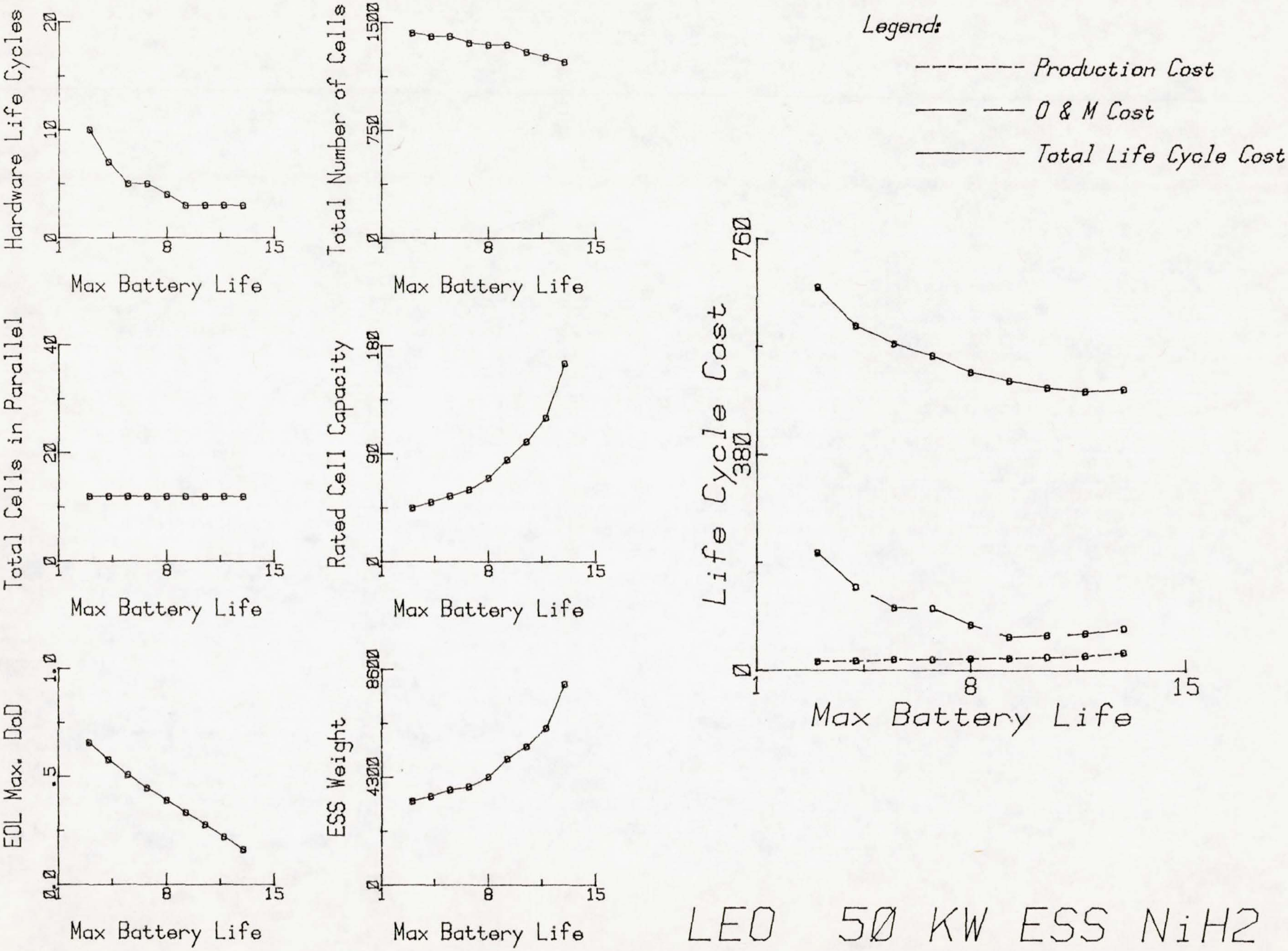


Exhibit 10b. Cell Life (Capacity Variable) Continued

LEO 100KW ESS (NiH2)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	10	7	5	5	4	3	3	3	3
Maximum Battery Life (Yr)	3.000	4.250	5.500	6.750	8.000	9.250	10.500	11.750	13.000
Rated Cell Capacity (AH)	85	95	110	120	140	165	195	240	325
Maximum Depth of Discharge	.657	.577	.508	.447	.390	.333	.277	.220	.162
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	77.188	77.188	77.188	77.188	77.188	77.188	77.188	77.188	77.188
Minimum Voltage (V)	1.085	1.102	1.110	1.148	1.157	1.153	1.193	1.233	1.274
Recharge Fraction	1.080	1.073	1.072	1.071	1.071	1.072	1.072	1.072	1.072
Charge Current (A)	57.245	56.874	56.789	56.784	56.784	56.789	56.789	56.789	56.789
Charge Voltage (V)	1.707	1.703	1.712	1.673	1.677	1.699	1.673	1.651	1.632
Watt-Hour Efficiency	.589	.603	.605	.641	.644	.633	.666	.697	.729
PHYSICAL CHARACTERISTICS									
Total Number of Cells	1428	1404	1404	1356	1344	1344	1296	1260	1224
Number of Parallel Batteries	12	12	12	12	12	12	12	12	12
Number of Modules per Battery	5	5	5	5	4	4	4	4	4
Battery Cell Weight (Kg)	1.928	2.155	2.495	2.722	3.175	3.742	4.423	5.443	7.371
Battery Cell Volume (Cm^3)	3825	3946	4128	4250	4492	4796	5160	5707	6741
ESS Weight (Kg)	6075	6472	7215	7436	8242	9437	10463	12149	15423
ESS Volume (M^3)	44.692	44.692	44.692	42.660	48.753	48.753	40.628	36.566	38.596
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	10.977	11.340	12.023	12.235	12.994	14.079	15.020	16.568	19.572
Production Cost	25.165	26.473	28.931	29.677	32.375	36.325	39.733	45.349	56.261
Operations & Maintenance Cost	254.584	181.185	133.535	136.142	102.407	78.827	84.116	92.702	109.270
ESS LIFE CYCLE COST	290.726	218.998	174.489	178.054	147.776	129.231	138.869	154.619	185.103
Solar Array Cost	750.837	735.443	737.919	704.086	700.553	708.065	679.017	657.020	635.976
Thermal Control Cost	14.496	14.085	14.406	12.932	13.050	13.762	12.733	11.959	11.295
Power Conditioning Cost	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645
TOTAL LIFE CYCLE COST	1057.704	970.171	928.459	896.717	863.024	852.703	832.264	825.243	834.019

Exhibit 10c. Cell Life (Capacity Variable)

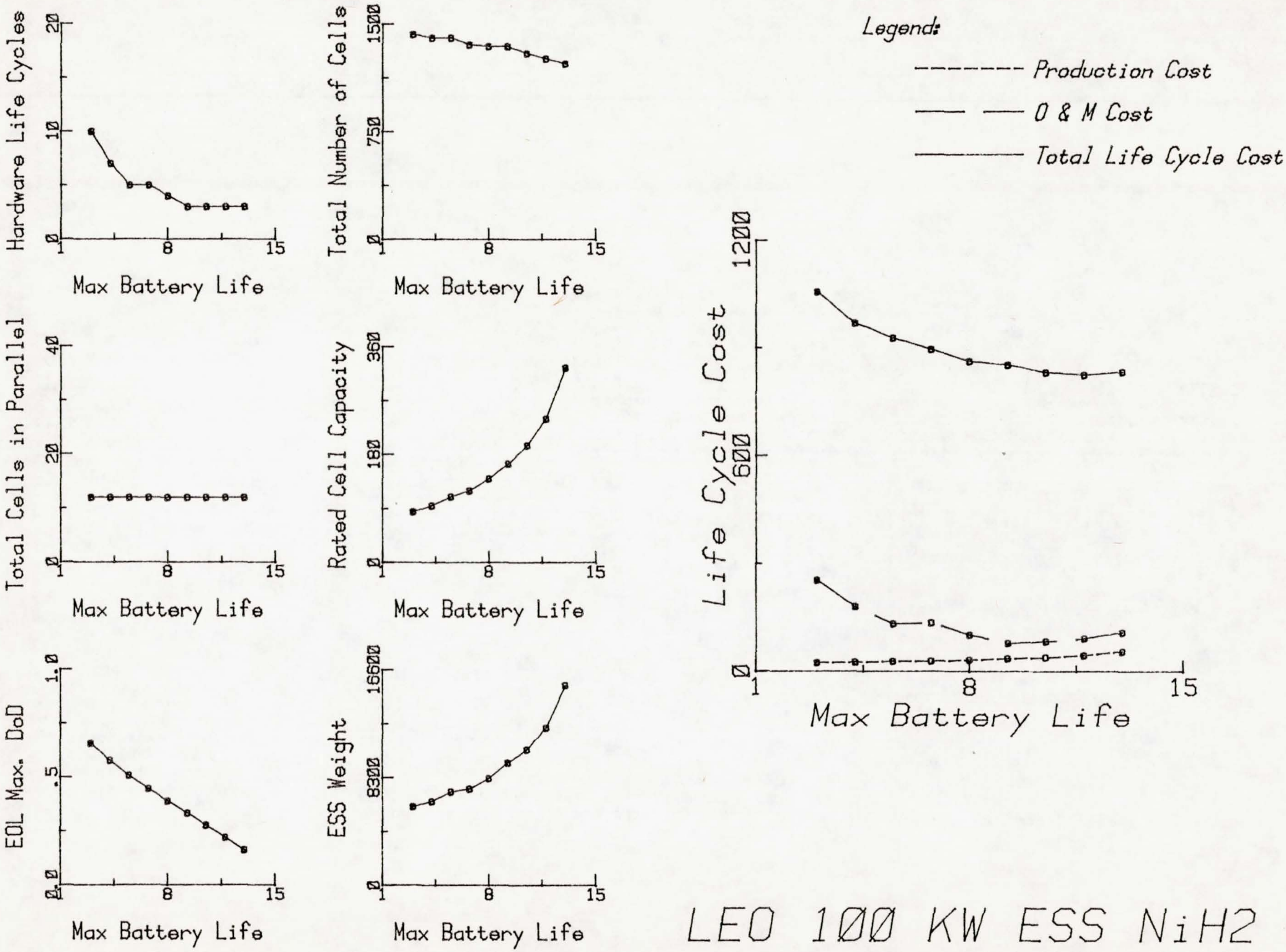


Exhibit 10c. Cell Life (Capacity Variable) Continued

LEO 250KW ESS (NiH2)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	10	7	5	5	4	3	3	3	3
Maximum Battery Life (Yr)	3.000	4.250	5.500	6.750	8.000	9.250	10.500	11.750	13.000
Rated Cell Capacity (AH)	105	120	135	150	175	205	245	300	405
Maximum Depth of Discharge	.657	.577	.508	.447	.390	.333	.277	.220	.162
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	96.485	96.485	96.485	96.485	96.485	96.485	96.485	96.485	96.485
Minimum Voltage (V)	1.085	1.103	1.109	1.148	1.157	1.153	1.194	1.233	1.274
Recharge Fraction	1.080	1.073	1.072	1.071	1.071	1.072	1.072	1.072	1.072
Charge Current (A)	71.555	71.091	70.985	70.978	70.978	70.985	70.985	70.985	70.985
Charge Voltage (V)	1.707	1.702	1.713	1.673	1.677	1.699	1.672	1.651	1.632
Watt-Hour Efficiency	.538	.604	.604	.641	.644	.633	.666	.697	.728
PHYSICAL CHARACTERISTICS									
Total Number of Cells	2856	2808	2808	2712	2688	2688	2592	2520	2448
Number of Parallel Batteries	24	24	24	24	24	24	24	24	24
Number of Modules per Battery	5	5	5	5	4	4	4	4	4
Battery Cell Weight (Kg)	2.381	2.722	3.062	3.402	3.969	4.649	5.557	6.804	9.185
Battery Cell Volume (Cm^3)	4067	4250	4432	4614	4918	5282	5768	6438	7714
ESS Weight (Kg)	14873	16110	17606	18399	20414	23286	26079	30182	38263
ESS Volume (M^3)	89.383	89.383	89.383	85.319	97.506	97.506	81.255	73.132	77.191
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	12.903	13.626	14.489	14.977	16.181	17.825	19.460	21.862	26.578
Production Cost	53.848	57.921	62.823	65.495	72.202	81.609	90.852	104.432	131.168
Operations & Maintenance Cost	534.004	385.432	282.390	291.292	222.050	171.470	185.731	206.420	246.853
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ESS LIFE CYCLE COST	600.755	456.979	359.702	371.764	310.433	270.904	296.043	332.714	404.599
Solar Array Cost	1567.266	1534.596	1540.391	1469.489	1462.117	1477.880	1417.133	1371.274	1327.319
Thermal Control Cost	28.451	27.389	28.234	24.526	24.824	26.606	24.027	22.095	20.435
Power Conditioning Cost	2.961	2.961	2.961	2.961	2.961	2.961	2.961	2.961	2.961
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TOTAL LIFE CYCLE COST	2199.433	2021.925	1931.288	1868.740	1800.335	1778.351	1740.164	1729.044	1755.314

Exhibit 10d. Cell Life (Capacity Variable)

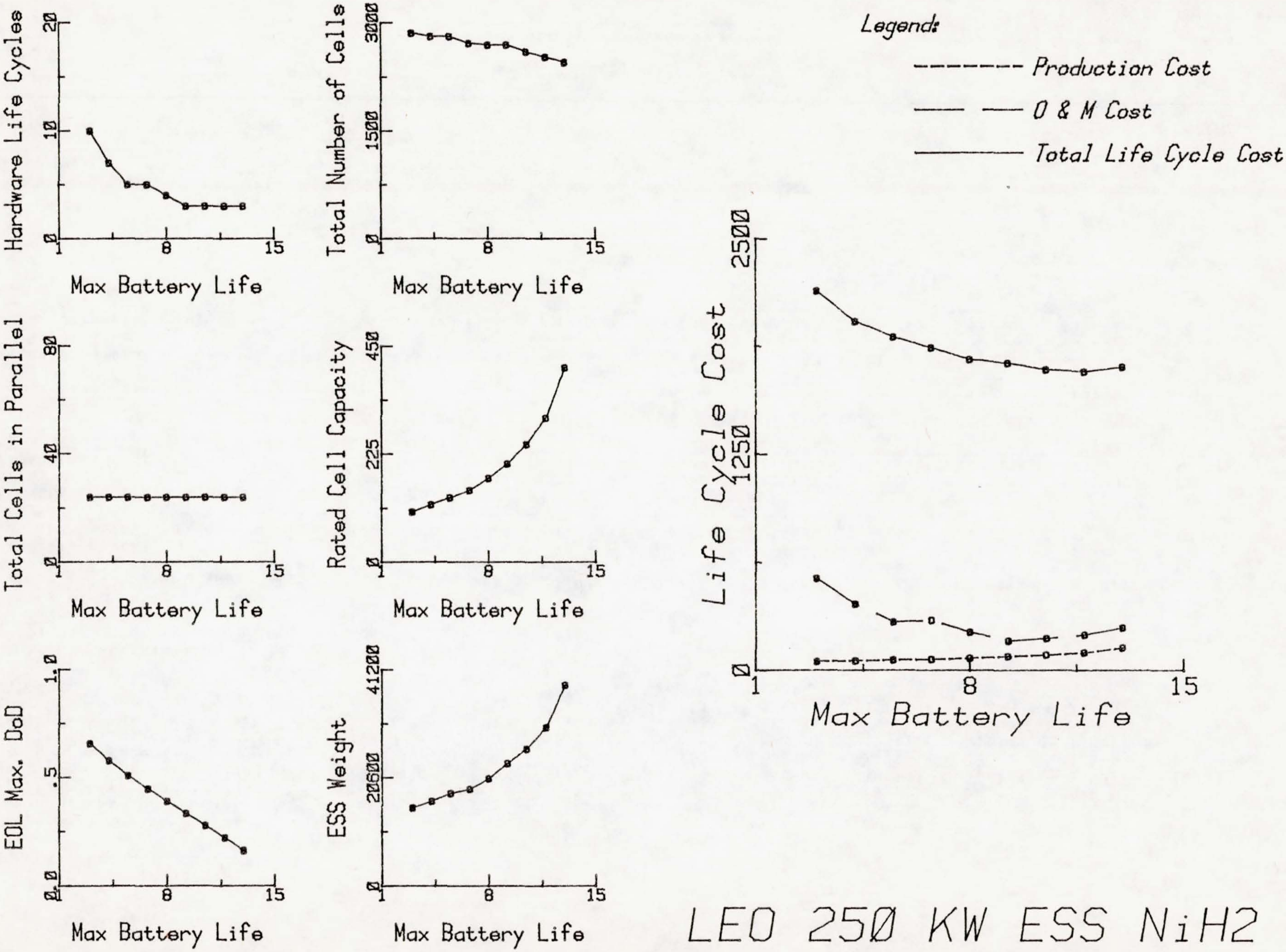

Exhibit 10d. Cell Life (Capacity Variable) Continued

GEO 25KW ESS (NIH2)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	1	1	1	1	1	1	1	1	1
Maximum Battery Life (Yr)	3.000	4.250	5.500	6.750	8.000	9.250	10.500	11.750	13.000
Rated Cell Capacity (AH)	35	40	45	55	60	70	85	105	145
Maximum Depth of Discharge	.657	.577	.508	.447	.390	.333	.277	.220	.162
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	19.297	19.297	19.297	19.297	19.297	19.297	19.297	19.297	19.297
Minimum Voltage (V)	1.245	1.266	1.291	1.322	1.338	1.359	1.379	1.396	1.418
Recharge Fraction	1.118	1.073	1.072	1.071	1.071	1.072	1.072	1.072	1.072
Charge Current (A)	1.122	1.077	1.075	1.075	1.075	1.075	1.075	1.075	1.075
Charge Voltage (V)	1.475	1.471	1.469	1.467	1.466	1.464	1.463	1.462	1.461
Watt-Hour Efficiency	.755	.801	.820	.841	.852	.866	.880	.891	.906
PHYSICAL CHARACTERISTICS									
Total Number of Cells	1248	1224	1200	1176	1164	1140	1128	1116	1092
Number of Parallel Batteries	12	12	12	12	12	12	12	12	12
Number of Modules per Battery	4	4	4	4	4	4	4	4	4
Battery Cell Weight (Kg)	.794	.907	1.021	1.247	1.361	1.588	1.928	2.381	3.289
Battery Cell Volume (Cm^3)	1772	1853	1936	3461	3521	3642	3825	4067	4553
ESS Weight (Kg)	2164	2343	2514	2879	3056	3398	3952	4688	6110
ESS Volume (M^3)	18.964	17.384	17.384	36.566	36.566	36.566	36.566	36.566	36.566
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	8.743	8.916	9.079	9.448	9.621	9.953	10.508	11.230	12.596
Production Cost	37.339	39.917	42.381	55.264	56.390	58.562	63.271	73.993	94.711
Operations & Maintenance Cost	.500	.500	.500	.500	.500	.500	.500	.500	.500
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ESS LIFE CYCLE COST	46.582	49.333	51.960	65.212	66.511	69.015	74.279	85.723	107.807
Solar Array Cost	11.528	10.962	10.762	10.575	10.432	10.302	10.209	10.115	9.931
Thermal Control Cost	5.754	5.689	5.615	5.528	5.484	5.425	5.373	5.331	5.277
Power Conditioning Cost	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645
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TOTAL LIFE CYCLE COST	65.509	67.629	69.982	82.960	84.122	86.387	91.506	102.814	124.660

Exhibit 10e. Cell Life (Capacity Variable)

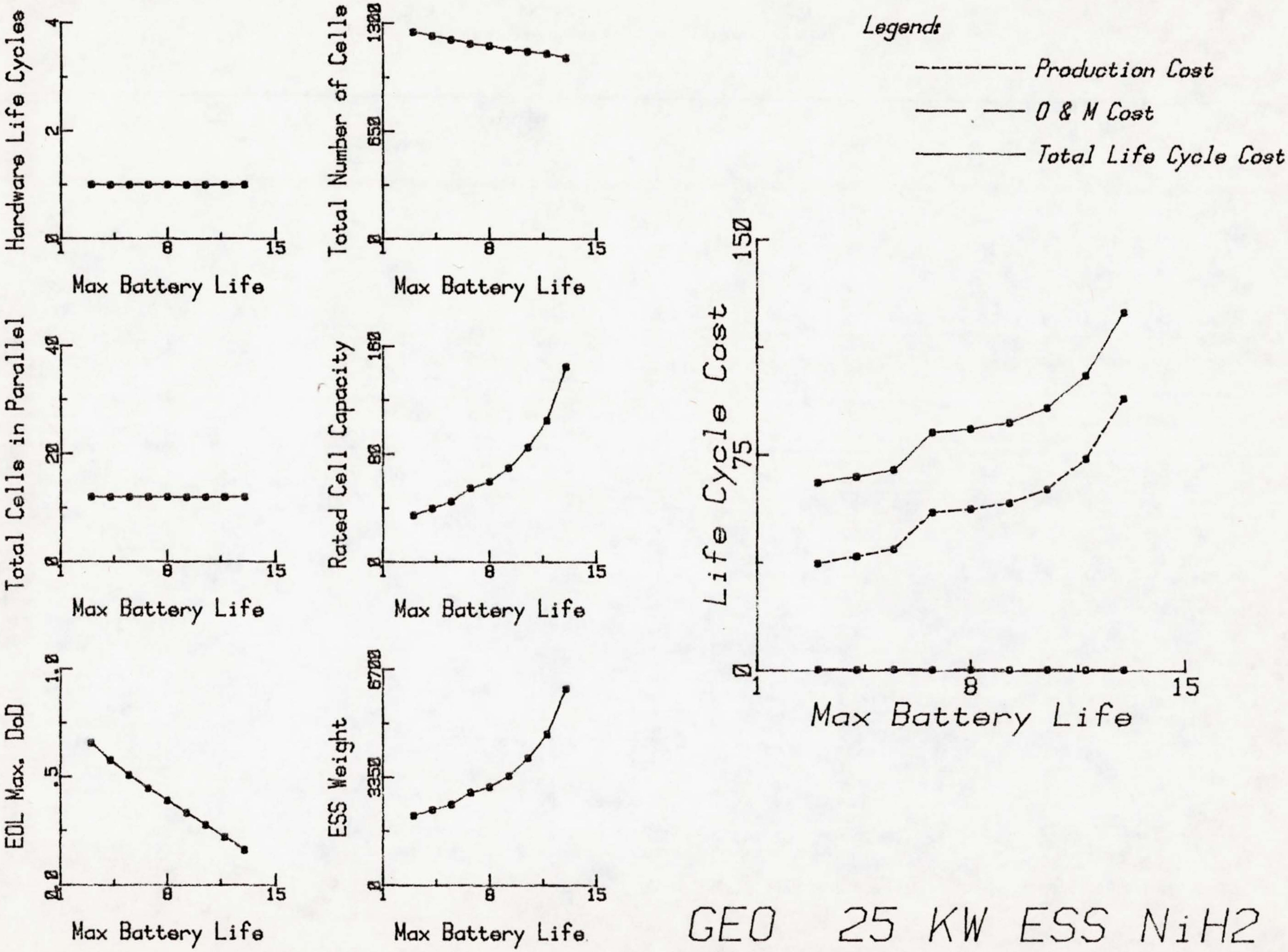

Exhibit 10e. Cell Life (Capacity Variable) Continued

LEO 25KW ESS (NIH2)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	3	3	4	5	6	8	12	20	40
Maximum Battery Life (Yr)	11.091	9.428	7.778	6.154	4.742	3.498	2.394	1.433	.690
Rated Cell Capacity (AH)	50	50	50	50	50	50	50	50	50
Maximum Depth of Discharge	.250	.325	.400	.475	.550	.625	.700	.775	.850
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	17.813	23.157	28.946	33.080	38.594	38.594	46.313	46.313	57.892
Minimum Voltage (V)	1.213	1.157	1.150	1.132	1.103	1.092	1.074	1.065	1.034
Recharge Fraction	1.071	1.071	1.072	1.072	1.072	1.077	1.085	1.094	1.114
Charge Current (A)	13.104	17.036	21.296	24.338	28.394	28.548	34.505	34.801	44.278
Charge Voltage (V)	1.662	1.695	1.683	1.689	1.709	1.713	1.717	1.720	1.746
Watt-Hour Efficiency	.682	.637	.638	.625	.602	.592	.577	.566	.531
PHYSICAL CHARACTERISTICS									
Total Number of Cells	1391	1120	904	798	702	708	600	605	500
Number of Parallel Batteries	13	10	8	7	6	6	5	5	4
Number of Modules per Battery	4	4	5	5	5	5	5	5	5
Battery Cell Weight (Kg)	1.134	1.134	1.134	1.134	1.134	1.134	1.134	1.134	1.134
Battery Cell Volume (Cm^3)	2020	2020	2020	2020	2020	2020	2020	2020	2020
ESS Weight (Kg)	3476	2598	2178	1965	1776	1791	1577	1590	1394
ESS Volume (M^3)	31.631	17.353	18.068	14.983	14.223	14.223	7.953	7.953	6.081
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	10.581	9.673	8.998	8.653	8.336	8.357	7.994	8.012	7.657
Production Cost	17.068	14.249	12.593	11.759	11.008	11.062	10.213	10.259	9.460
Operations & Maintenance Cost	54.288	43.209	55.824	63.585	67.900	92.007	122.070	206.317	351.932
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ESS LIFE CYCLE COST	81.937	67.131	77.415	83.997	87.244	111.426	140.277	224.588	369.049
Solar Array Cost	220.242	232.158	232.497	234.816	242.007	245.229	250.416	254.155	267.895
Thermal Control Cost	6.993	7.312	7.223	7.275	7.465	7.557	7.656	7.760	8.156
Power Conditioning Cost	1.761	1.409	1.166	1.042	.914	.914	.783	.783	.648
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TOTAL LIFE CYCLE COST	310.933	308.010	318.301	327.130	337.630	365.126	399.132	487.286	645.748

Exhibit 11a. Depth of Discharge (Capacity Fixed)

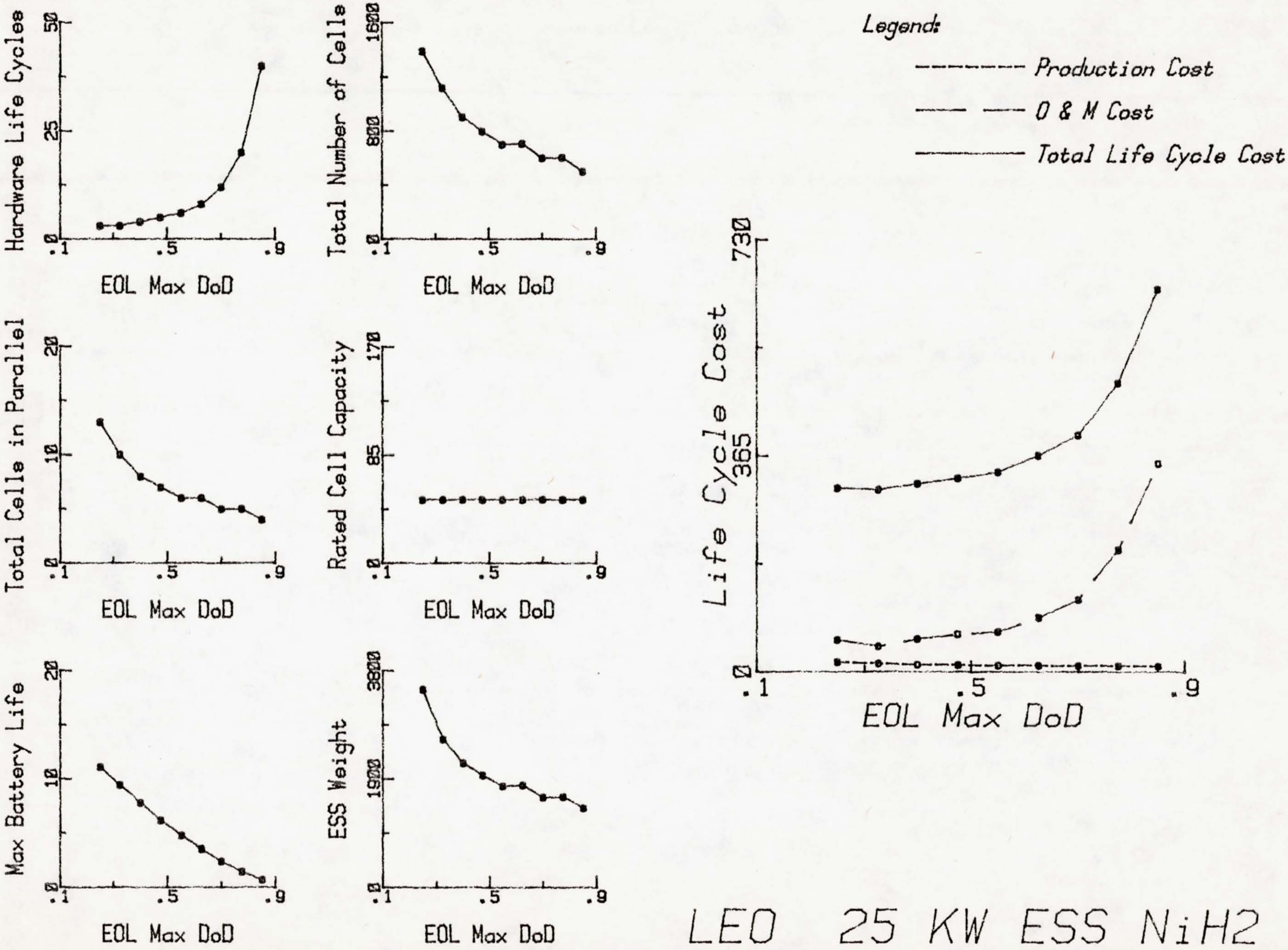

Exhibit 11a. Depth of Discharge (Capacity Fixed) Continued

LEO 50KW ESS (NIH2)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	3	3	4	5	6	8	12	20	40
Maximum Battery Life (Yr)	11.091	9.428	7.778	6.154	4.742	3.498	2.394	1.433	.690
Rated Cell Capacity (AH)	50	50	50	50	50	50	50	50	50
Maximum Depth of Discharge	.250	.325	.400	.475	.550	.625	.700	.775	.850
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	17.813	23.157	28.946	33.080	38.594	42.103	46.313	51.459	57.892
Minimum Voltage (V)	1.213	1.157	1.150	1.132	1.103	1.086	1.074	1.061	1.034
Recharge Fraction	1.071	1.071	1.072	1.072	1.072	1.077	1.085	1.094	1.114
Charge Current (A)	13.104	17.036	21.296	24.338	28.394	31.143	34.505	38.668	44.278
Charge Voltage (V)	1.662	1.695	1.683	1.689	1.709	1.716	1.717	1.725	1.746
Watt-Hour Efficiency	.682	.637	.638	.625	.602	.587	.577	.562	.531
PHYSICAL CHARACTERISTICS									
Total Number of Cells	2782	2240	1808	1596	1404	1309	1200	1098	1000
Number of Parallel Batteries	26	20	16	14	12	11	10	9	8
Number of Modules per Battery	4	4	5	5	5	5	5	5	5
Battery Cell Weight (Kg)	1.134	1.134	1.134	1.134	1.134	1.134	1.134	1.134	1.134
Battery Cell Volume (Cm^3)	2020	2020	2020	2020	2020	2020	2020	2020	2020
ESS Weight (Kg)	6950	5611	4355	3929	3551	3726	3152	3216	2788
ESS Volume (M^3)	63.263	59.931	36.137	29.965	28.446	28.446	15.907	15.907	18.928
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	13.762	12.250	11.017	10.417	9.869	9.654	9.281	9.031	8.704
Production Cost	29.411	25.319	20.546	18.893	17.408	17.430	15.837	15.599	14.351
Operations & Maintenance Cost	103.542	82.755	105.016	117.864	125.076	157.385	219.550	340.284	623.067
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ESS LIFE CYCLE COST	146.715	120.324	136.579	147.174	152.353	184.469	244.668	364.914	646.122
Solar Array Cost	384.257	405.052	405.639	409.685	422.236	431.416	436.907	447.417	467.408
Thermal Control Cost	8.784	9.423	9.247	9.348	9.729	9.983	10.110	10.411	11.111
Power Conditioning Cost	3.169	2.537	2.100	1.875	1.645	1.528	1.409	1.289	1.166
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TOTAL LIFE CYCLE COST	542.925	537.336	553.565	568.082	585.963	627.396	693.094	824.031	1125.807

Exhibit 11b. Depth of Discharge (Capacity Fixed)

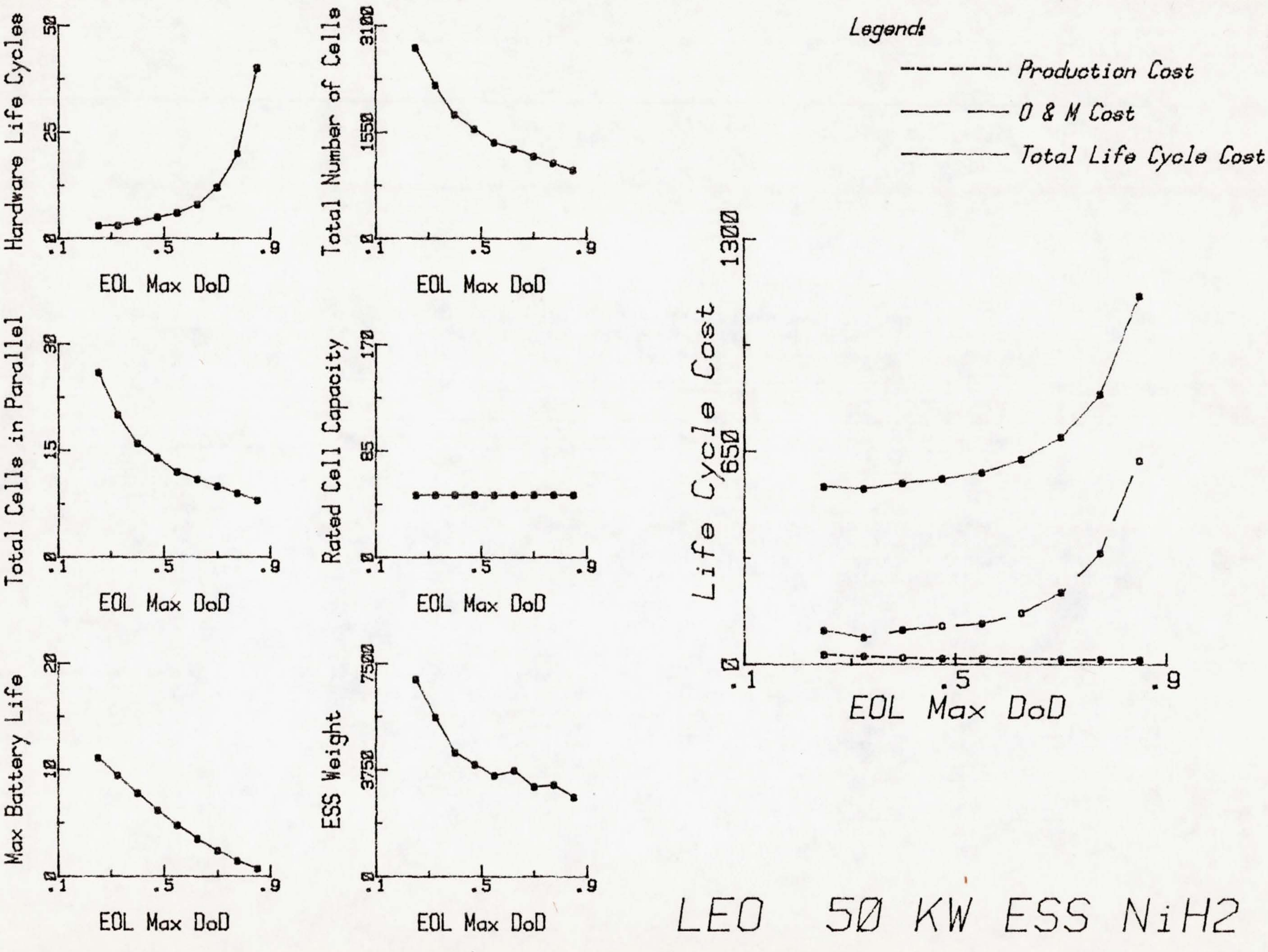

Exhibit 11b. Depth of Discharge (Capacity Fixed) Continued

LEO 100KW ESS (NIH2)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	3	3	4	5	6	8	12	20	40
Maximum Battery Life (Yr)	11.091	9.428	7.778	6.154	4.742	3.498	2.394	1.433	.690
Rated Cell Capacity (AH)	50	50	50	50	50	50	50	50	50
Maximum Depth of Discharge	.250	.325	.400	.475	.550	.625	.700	.775	.850
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	18.163	23.157	28.946	34.306	38.594	44.108	48.750	54.485	57.892
Minimum Voltage (V)	1.211	1.157	1.150	1.130	1.103	1.082	1.072	1.058	1.034
Recharge Fraction	1.071	1.071	1.072	1.072	1.072	1.077	1.085	1.094	1.114
Charge Current (A)	13.362	17.036	21.296	25.240	28.394	32.627	36.321	40.942	44.278
Charge Voltage (V)	1.662	1.695	1.683	1.690	1.709	1.718	1.719	1.727	1.746
Watt-Hour Efficiency	.680	.637	.638	.624	.602	.584	.575	.560	.531
PHYSICAL CHARACTERISTICS									
Total Number of Cells	5457	4480	3616	3105	2808	2520	2299	2074	2000
Number of Parallel Batteries	51	40	32	27	24	21	19	17	16
Number of Modules per Battery	4	4	5	5	5	5	5	5	5
Battery Cell Weight (Kg)	1.134	1.134	1.134	1.134	1.134	1.134	1.134	1.134	1.134
Battery Cell Volume (Cm^3)	2020	2020	2020	2020	2020	2020	2020	2020	2020
ESS Weight (Kg)	13819	10390	8708	7992	7102	6537	6727	6033	5575
ESS Volume (M^3)	114.430	103.240	72.273	59.931	56.784	44.948	44.948	42.669	37.856
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	19.757	17.193	15.039	13.754	12.964	12.220	11.702	11.095	10.875
Production Cost	53.335	42.776	36.298	33.003	30.096	27.897	27.505	25.257	24.044
Operations & Maintenance Cost	197.934	158.703	202.890	219.701	238.779	286.796	397.502	605.534	1161.638
ESS LIFE CYCLE COST	271.026	218.672	254.227	266.458	281.839	326.913	436.709	641.886	1196.557
Solar Array Cost	670.555	706.712	707.737	720.174	736.702	758.464	768.203	781.676	815.507
Thermal Control Cost	12.376	13.645	13.292	13.588	14.258	14.883	15.144	15.676	17.023
Power Conditioning Cost	5.611	4.566	3.779	3.272	2.961	2.644	2.429	2.210	2.100
TOTAL LIFE CYCLE COST	959.568	943.595	979.035	1003.492	1035.760	1102.904	1222.485	1441.448	2031.187

Exhibit 11c. Depth of Discharge (Capacity Fixed)

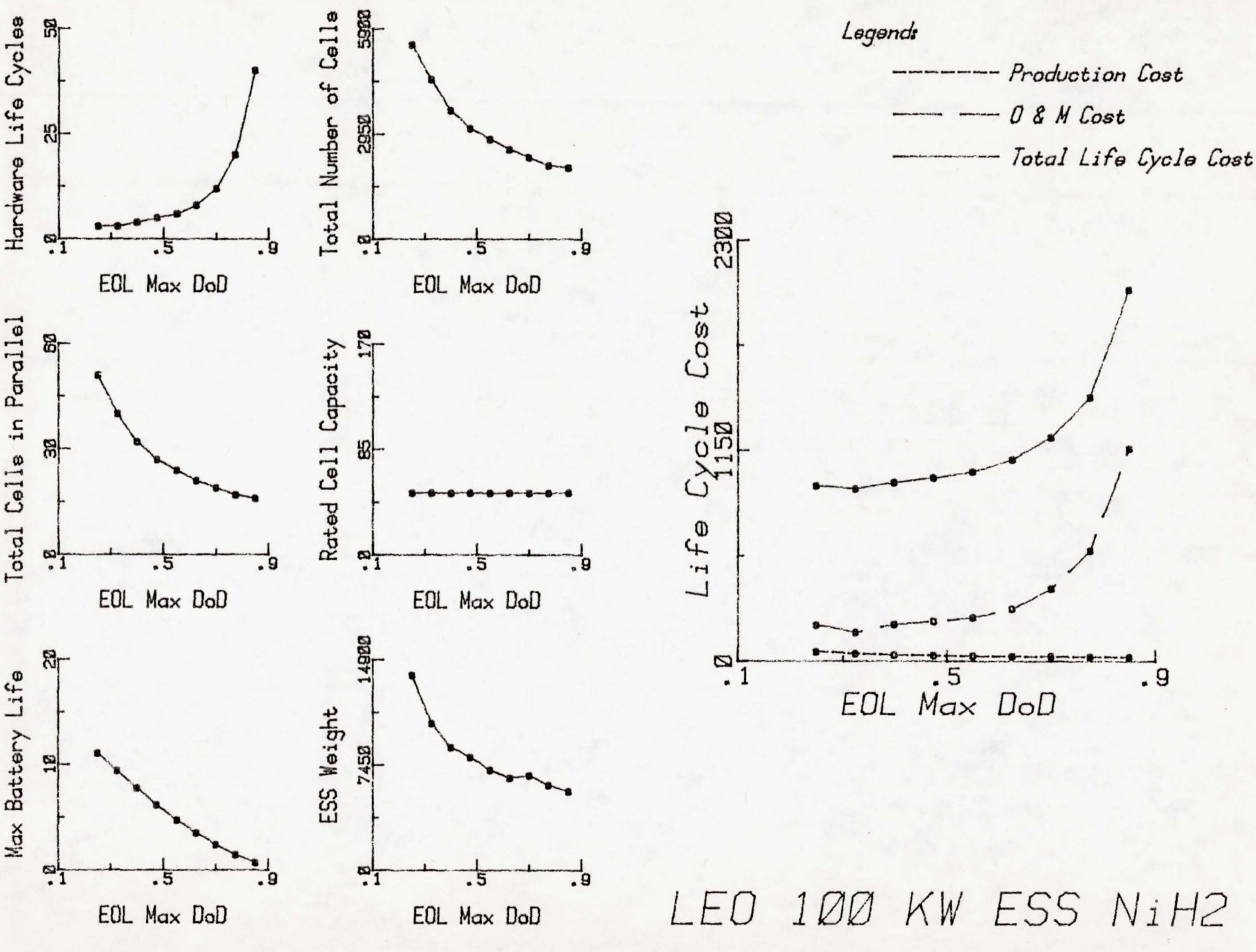

Exhibit 11c. Depth of Discharge (Capacity Fixed) Continued

LEO 250KW ESS (NIH2)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	3	3	4	5	6	8	12	20	40
Maximum Battery Life (Yr)	11.091	9.428	7.778	6.154	4.742	3.498	2.394	1.433	.690
Rated Cell Capacity (AH)	50	50	50	50	50	50	50	50	50
Maximum Depth of Discharge	.250	.325	.400	.475	.550	.625	.700	.775	.850
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	18.090	23.157	28.946	34.054	39.248	44.531	49.268	55.135	59.375
Minimum Voltage (V)	1.212	1.157	1.150	1.130	1.102	1.081	1.071	1.057	1.032
Recharge Fraction	1.071	1.071	1.072	1.072	1.072	1.077	1.085	1.094	1.114
Charge Current (A)	13.308	17.036	21.296	25.054	28.875	32.939	36.707	41.430	44.425
Charge Voltage (V)	1.662	1.695	1.683	1.690	1.709	1.719	1.720	1.728	1.746
Watt-Hour Efficiency	.681	.637	.638	.624	.602	.584	.574	.559	.531
PHYSICAL CHARACTERISTICS									
Total Number of Cells	13696	11200	9040	7752	6903	6240	5687	5124	4875
Number of Parallel Batteries	128	100	80	68	59	52	47	42	39
Number of Modules per Battery	4	4	5	5	5	5	5	5	5
Battery Cell Weight (Kg)	1.134	1.134	1.134	1.134	1.134	1.134	1.134	1.134	1.134
Battery Cell Volume (Cm^3)	2020	2020	2020	2020	2020	2020	2020	2020	2020
ESS Weight (Kg)	31022	27441	21769	20469	19201	17567	15473	14063	13995
ESS Volume (M^3)	261.560	268.430	180.680	162.620	151.420	132.500	113.570	89.896	94.640
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	27.229	23.286	19.834	17.801	16.444	15.351	14.404	13.469	13.084
Production Cost	118.059	102.107	83.066	75.931	70.373	64.675	58.398	53.512	52.517
Operations & Maintenance Cost	487.071	387.889	494.857	534.996	568.794	683.195	942.752	1426.431	2702.478
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ESS LIFE CYCLE COST	632.359	513.282	597.757	628.728	655.611	763.221	1015.554	1493.412	2768.079
Solar Array Cost	1399.333	1474.970	1477.127	1492.441	1537.952	1583.168	1603.696	1631.812	1672.371
Thermal Control Cost	23.131	26.311	25.430	25.971	27.868	29.415	30.082	31.415	34.116
Power Conditioning Cost	12.245	9.932	8.220	7.161	6.349	5.704	5.236	4.759	4.469
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TOTAL LIFE CYCLE COST	2067.068	2024.495	2108.534	2154.301	2227.780	2381.508	2654.568	3161.398	4479.035

Exhibit 11d. Depth of Discharge (Capacity Fixed)

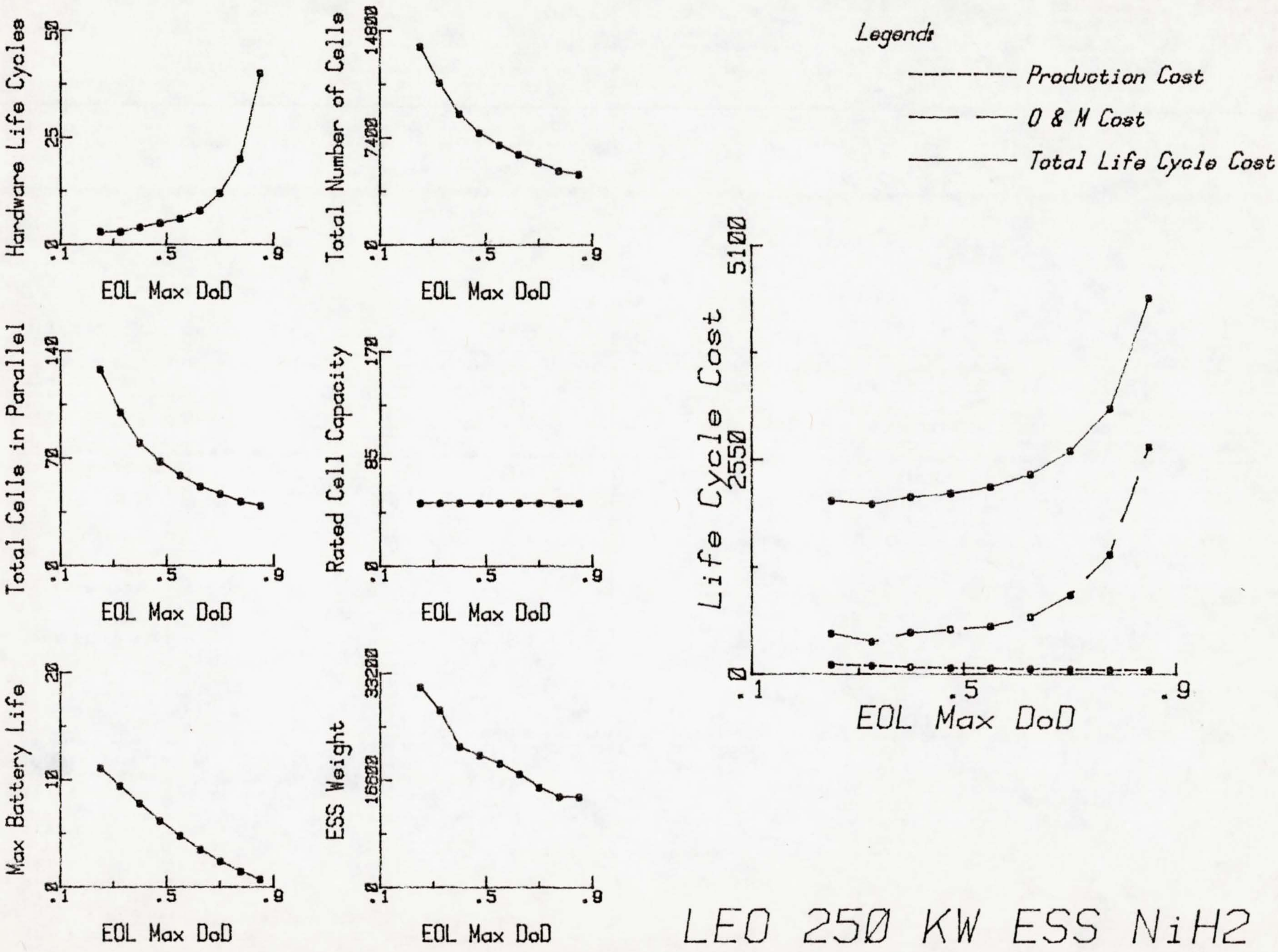

Exhibit 11d. Depth of Discharge (Capacity Fixed) Continued

GEO 25KW ESS (NiH2)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	1	1	1	1	1	1	1	1	1
Maximum Battery Life (Yr)	11.091	9.428	7.778	6.154	4.742	3.498	2.394	1.433	.690
Rated Cell Capacity (AH)	50	50	50	50	50	50	50	50	50
Maximum Depth of Discharge	.250	.325	.400	.475	.550	.625	.700	.775	.850
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	10.526	13.622	16.541	19.297	23.156	25.729	28.946	28.946	33.080
Minimum Voltage (V)	1.386	1.361	1.334	1.308	1.275	1.253	1.236	1.223	1.193
Recharge Fraction	1.071	1.071	1.072	1.072	1.072	1.094	1.157	1.327	1.577
Charge Current (A)	.586	.759	.922	1.075	1.290	1.464	1.741	1.997	3.631
Charge Voltage (V)	1.463	1.464	1.466	1.468	1.470	1.473	1.478	1.486	1.507
Watt-Hour Efficiency	.884	.867	.849	.831	.809	.777	.723	.620	.375
PHYSICAL CHARACTERISTICS									
Total Number of Cells	2046	1615	1358	1188	1020	927	840	848	756
Number of Parallel Batteries	22	17	14	12	10	9	8	8	7
Number of Modules per Battery	4	4	4	4	4	4	4	4	4
Battery Cell Weight (Kg)	1.134	1.134	1.134	1.134	1.134	1.134	1.134	1.134	1.134
Battery Cell Volume (Cm^3)	2020	2020	2020	2020	2020	2020	2020	2020	2020
ESS Weight (Kg)	5034	3805	3051	2698	2350	2349	1982	1997	1810
ESS Volume (M^3)	46.460	26.076	29.965	17.384	10.122	11.568	14.626	15.487	16.647
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	11.752	10.521	9.756	9.267	8.772	8.544	8.232	8.256	7.975
Production Cost	79.314	61.370	50.382	45.053	39.793	39.438	34.222	34.451	31.616
Operations & Maintenance Cost	.500	.500	.500	.500	.500	.500	.500	.500	.500
ESS LIFE CYCLE COST	91.566	72.391	60.638	54.820	49.065	48.482	42.954	43.207	40.091
Solar Array Cost	10.121	10.301	10.487	10.669	10.941	11.234	11.960	13.513	20.144
Thermal Control Cost	5.355	5.421	5.494	5.567	5.665	5.728	5.780	5.811	5.881
Power Conditioning Cost	2.750	2.210	1.875	1.645	1.409	1.289	1.166	1.166	1.042
TOTAL LIFE CYCLE COST	109.792	90.323	78.494	72.701	67.080	66.733	61.860	63.697	67.158

Exhibit 11e. Depth of Discharge (Capacity Fixed)

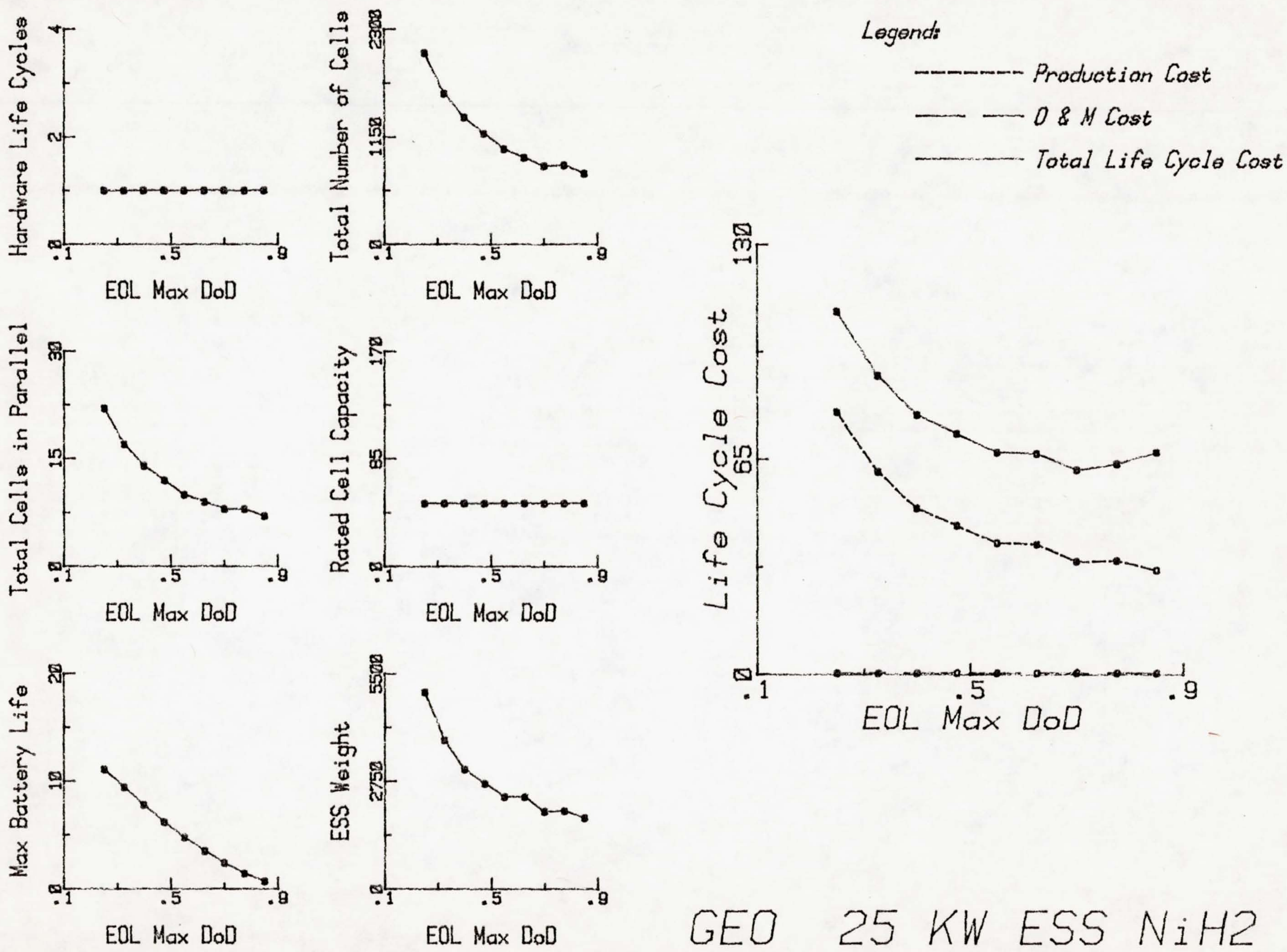

Exhibit 11e. Depth of Discharge (Capacity Fixed) Continued

LEO 25KW ESS (NIH2)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	10	7	5	5	4	3	3	3	3
Maximum Battery Life (Yr)	3.000	4.250	5.500	6.750	8.000	9.250	10.500	11.750	13.000
Rated Cell Capacity (AH)	50	50	50	50	50	50	50	50	50
Maximum Depth of Discharge	.657	.577	.508	.447	.390	.333	.277	.220	.162
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	46.313	38.594	33.080	28.946	25.729	23.157	19.298	15.438	11.579
Minimum Voltage (V)	1.084	1.106	1.114	1.154	1.160	1.153	1.196	1.236	1.276
Recharge Fraction	1.080	1.073	1.072	1.071	1.071	1.072	1.072	1.072	1.072
Charge Current (A)	34.346	28.436	24.338	21.294	18.927	17.038	14.198	11.358	8.519
Charge Voltage (V)	1.707	1.701	1.711	1.670	1.675	1.699	1.672	1.651	1.631
Watt-Hour Efficiency	.588	.606	.608	.645	.646	.633	.668	.699	.730
PHYSICAL CHARACTERISTICS									
Total Number of Cells	595	702	812	896	1008	1120	1296	1575	2020
Number of Parallel Batteries	5	6	7	8	9	10	12	15	20
Number of Modules per Battery	5	5	5	4	4	4	4	4	4
Battery Cell Weight (Kg)	1.134	1.134	1.134	1.134	1.134	1.134	1.134	1.134	1.134
Battery Cell Volume (Cm^3)	2020	2020	2020	2020	2020	2020	2020	2020	2020
ESS Weight (Kg)	1562	1774	1998	2138	2648	2600	2955	3782	4734
ESS Volume (M^3)	7.953	14.223	14.983	20.649	17.353	17.353	18.964	29.252	42.452
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	7.975	8.335	8.702	8.955	9.384	9.673	10.221	11.125	12.456
Production Cost	10.163	11.003	11.881	12.466	13.943	14.253	15.635	18.373	21.965
Operations & Maintenance Cost	100.890	79.837	63.899	62.694	54.296	43.209	50.420	61.217	79.078
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ESS LIFE CYCLE COST	119.028	99.175	84.482	84.115	77.623	67.135	76.276	90.715	113.499
Solar Array Cost	246.738	241.393	240.539	229.373	229.967	232.594	223.022	215.787	207.213
Thermal Control Cost	7.527	7.414	7.475	7.106	7.156	7.341	7.082	6.888	6.706
Power Conditioning Cost	.783	.914	1.042	1.166	1.289	1.409	1.645	1.988	2.537
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TOTAL LIFE CYCLE COST	374.076	348.896	333.538	321.760	316.035	308.479	308.025	315.378	329.955

Exhibit 12a. Cell Life (Capacity Fixed)

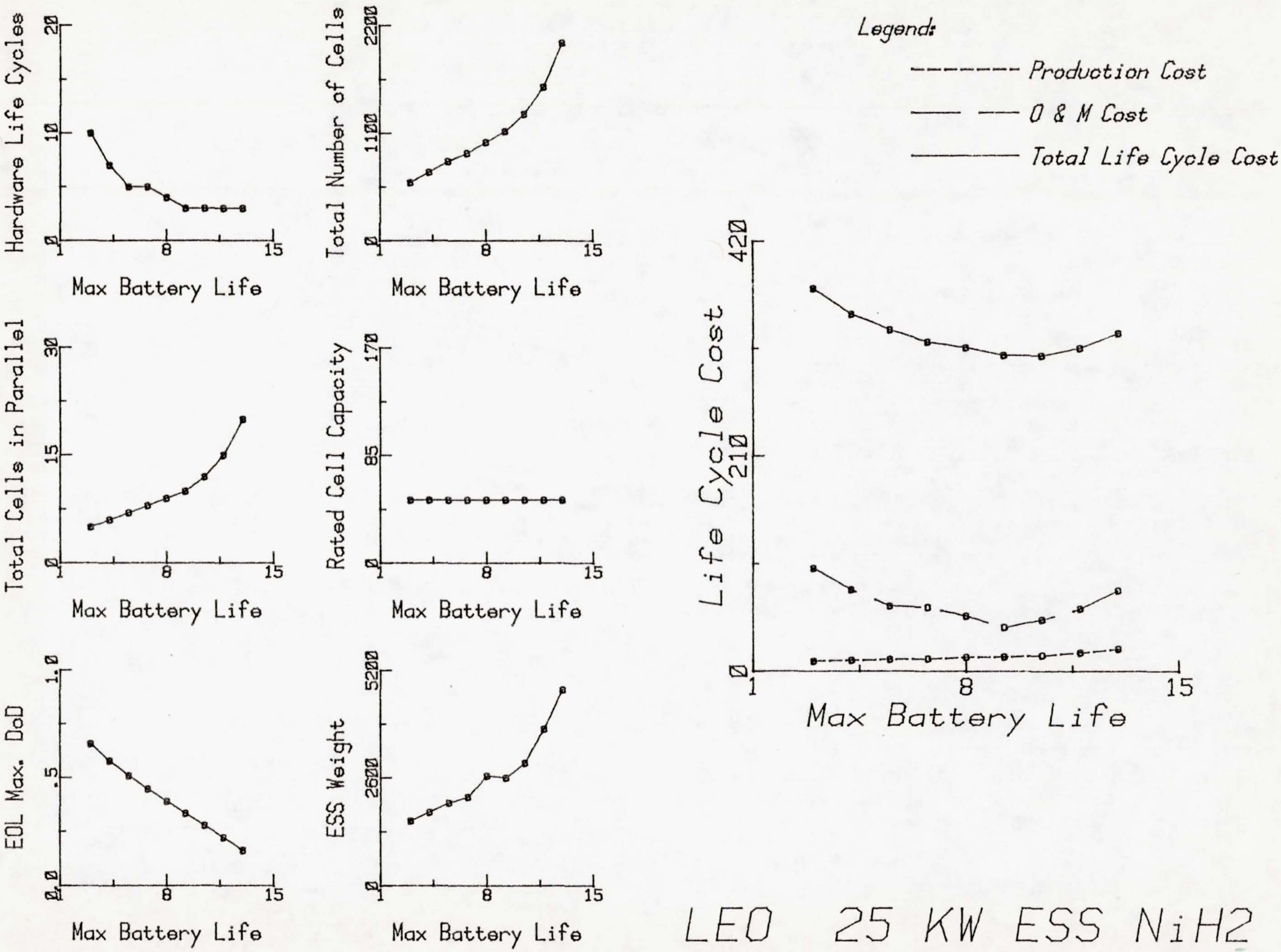

Exhibit 12a. Cell Life (Capacity Fixed) Continued

LEO 50KW ESS (NiH2)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	10	7	5	5	4	3	3	3	3
Maximum Battery Life (Yr)	3.000	4.250	5.500	6.750	8.000	9.250	10.500	11.750	13.000
Rated Cell Capacity (AH)	50	50	50	50	50	50	50	50	50
Maximum Depth of Discharge	.657	.577	.508	.447	.390	.333	.277	.220	.162
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	46.313	38.594	35.626	30.875	27.243	23.157	19.298	15.970	11.875
Minimum Voltage (V)	1.084	1.106	1.109	1.150	1.158	1.153	1.196	1.233	1.274
Recharge Fraction	1.080	1.073	1.072	1.071	1.071	1.072	1.072	1.072	1.072
Charge Current (A)	34.346	28.436	26.211	22.713	20.041	17.038	14.198	11.750	8.737
Charge Voltage (V)	1.707	1.701	1.713	1.672	1.677	1.699	1.672	1.651	1.632
Watt-Hour Efficiency	.588	.606	.604	.642	.644	.633	.668	.697	.729
PHYSICAL CHARACTERISTICS									
Total Number of Cells	1190	1404	1521	1680	1904	2240	2592	3045	3978
Number of Parallel Batteries	10	12	13	15	17	20	24	29	39
Number of Modules per Battery	5	5	5	4	4	4	4	4	4
Battery Cell Weight (Kg)	1.134	1.134	1.134	1.134	1.134	1.134	1.134	1.134	1.134
Battery Cell Volume (Cm^3)	2020	2020	2020	2020	2020	2020	2020	2020	2020
ESS Weight (Kg)	3124	3547	4101	4418	4746	5614	5909	7610	9018
ESS Volume (M^3)	15.907	28.446	29.965	41.297	28.446	59.931	51.622	58.505	77.433
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	9.249	9.868	10.252	10.678	11.291	12.251	13.168	14.490	16.949
Production Cost	15.740	17.400	18.982	20.184	21.675	25.320	26.561	31.723	37.954
Operations & Maintenance Cost	181.614	146.844	111.357	109.064	96.397	82.745	96.205	114.110	150.147
ESS LIFE CYCLE COST	206.603	174.112	140.591	139.926	129.363	120.316	135.934	160.323	205.050
Solar Array Cost	430.486	421.165	423.027	400.490	401.494	405.818	389.107	376.575	364.533
Thermal Control Cost	9.854	9.626	9.807	9.024	9.123	9.480	8.962	8.579	8.248
Power Conditioning Cost	1.409	1.645	1.761	1.988	2.210	2.537	2.961	3.477	4.469
TOTAL LIFE CYCLE COST	648.352	606.548	575.186	551.428	542.190	538.151	536.964	548.954	582.300

Exhibit 12b. Cell Life (Capacity Fixed)

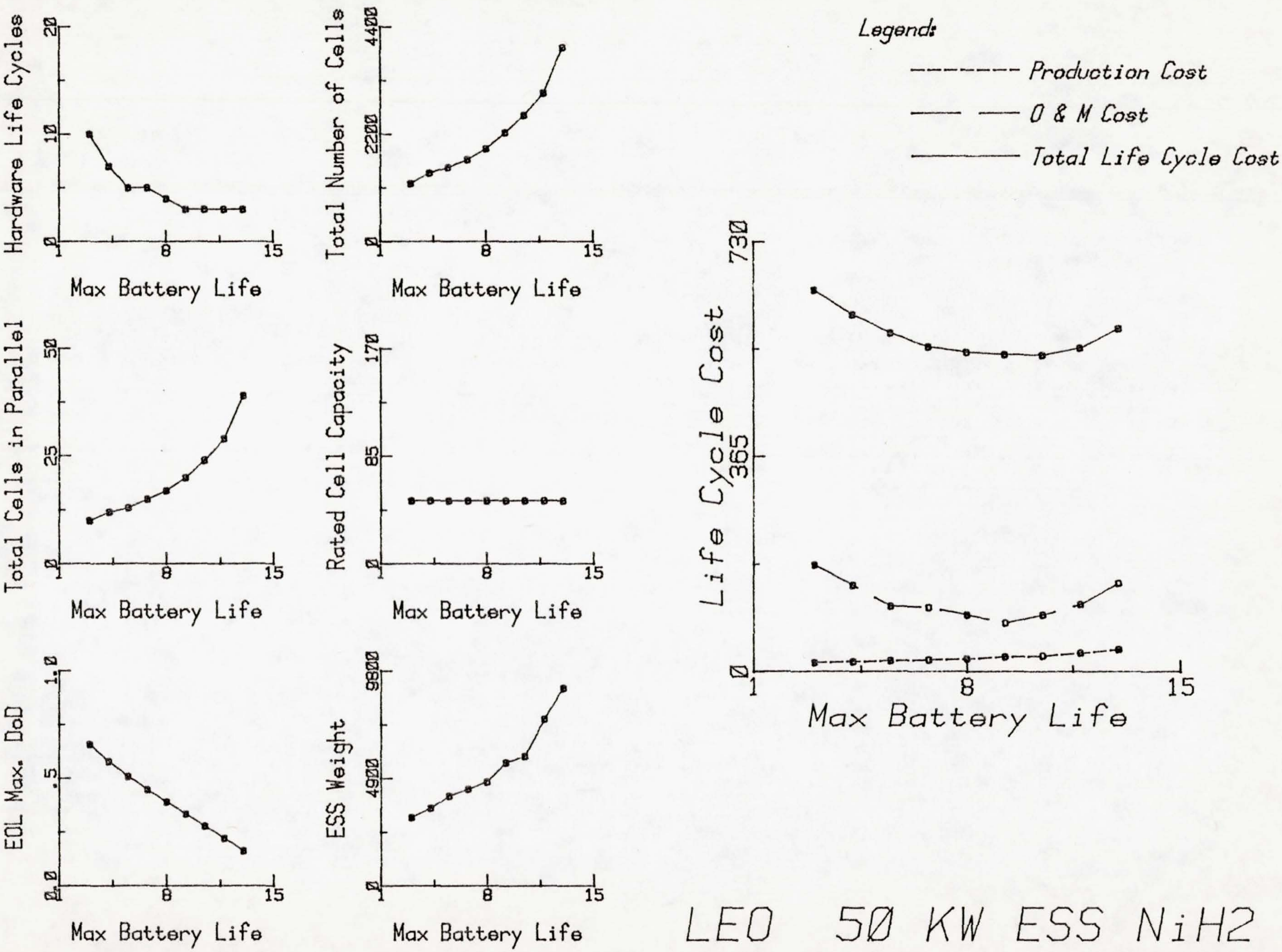

Exhibit 12b. Cell Life (Capacity Fixed) Continued

LEO 100KW ESS (NiH2)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	10	7	5	5	4	3	3	3	3
Maximum Battery Life (Yr)	3.000	4.250	5.500	6.750	8.000	9.250	10.500	11.750	13.000
Rated Cell Capacity (AH)	50	50	50	50	50	50	50	50	50
Maximum Depth of Discharge	.657	.577	.508	.447	.390	.333	.277	.220	.162
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	46.313	40.272	35.626	31.940	28.069	23.750	19.709	15.970	11.875
Minimum Voltage (V)	1.084	1.103	1.109	1.148	1.156	1.152	1.194	1.233	1.274
Recharge Fraction	1.080	1.073	1.072	1.071	1.071	1.072	1.072	1.072	1.072
Charge Current (A)	34.346	29.674	26.211	23.497	20.649	17.473	14.501	11.750	8.737
Charge Voltage (V)	1.707	1.702	1.713	1.672	1.677	1.699	1.672	1.651	1.632
Watt-Hour Efficiency	.588	.604	.604	.641	.643	.633	.666	.697	.729
PHYSICAL CHARACTERISTICS									
Total Number of Cells	2380	2691	3042	3277	3696	4368	5076	6090	7956
Number of Parallel Batteries	20	23	26	29	33	39	47	58	78
Number of Modules per Battery	5	5	5	5	4	4	4	4	4
Battery Cell Weight (Kg)	1.134	1.134	1.134	1.134	1.134	1.134	1.134	1.134	1.134
Battery Cell Volume (Cm^3)	2020	2020	2020	2020	2020	2020	2020	2020	2020
ESS Weight (Kg)	6558	7196	8201	8973	9618	10537	11904	15219	18034
ESS Volume (M^3)	44.948	56.784	59.931	72.273	99.884	103.240	103.240	117.010	154.870
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	11.881	12.690	13.622	14.244	15.257	16.939	18.727	21.354	25.958
Production Cost	27.438	29.876	33.219	35.652	38.937	42.697	48.021	58.456	70.777
Operations & Maintenance Cost	343.236	269.616	212.874	233.741	181.699	155.059	183.339	222.936	294.695
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ESS LIFE CYCLE COST	382.555	312.182	259.715	283.637	235.893	214.695	250.087	302.746	391.430
Solar Array Cost	751.079	735.321	738.082	704.086	700.759	708.106	679.058	657.020	636.018
Thermal Control Cost	14.508	14.078	14.413	12.930	13.058	13.765	12.731	11.957	11.297
Power Conditioning Cost	2.537	2.856	3.169	3.477	3.879	4.469	5.236	6.258	8.045
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TOTAL LIFE CYCLE COST	1150.679	1064.437	1015.379	1004.130	953.589	941.035	947.112	977.981	1046.790

Exhibit 12c. Cell Life (Capacity Fixed)

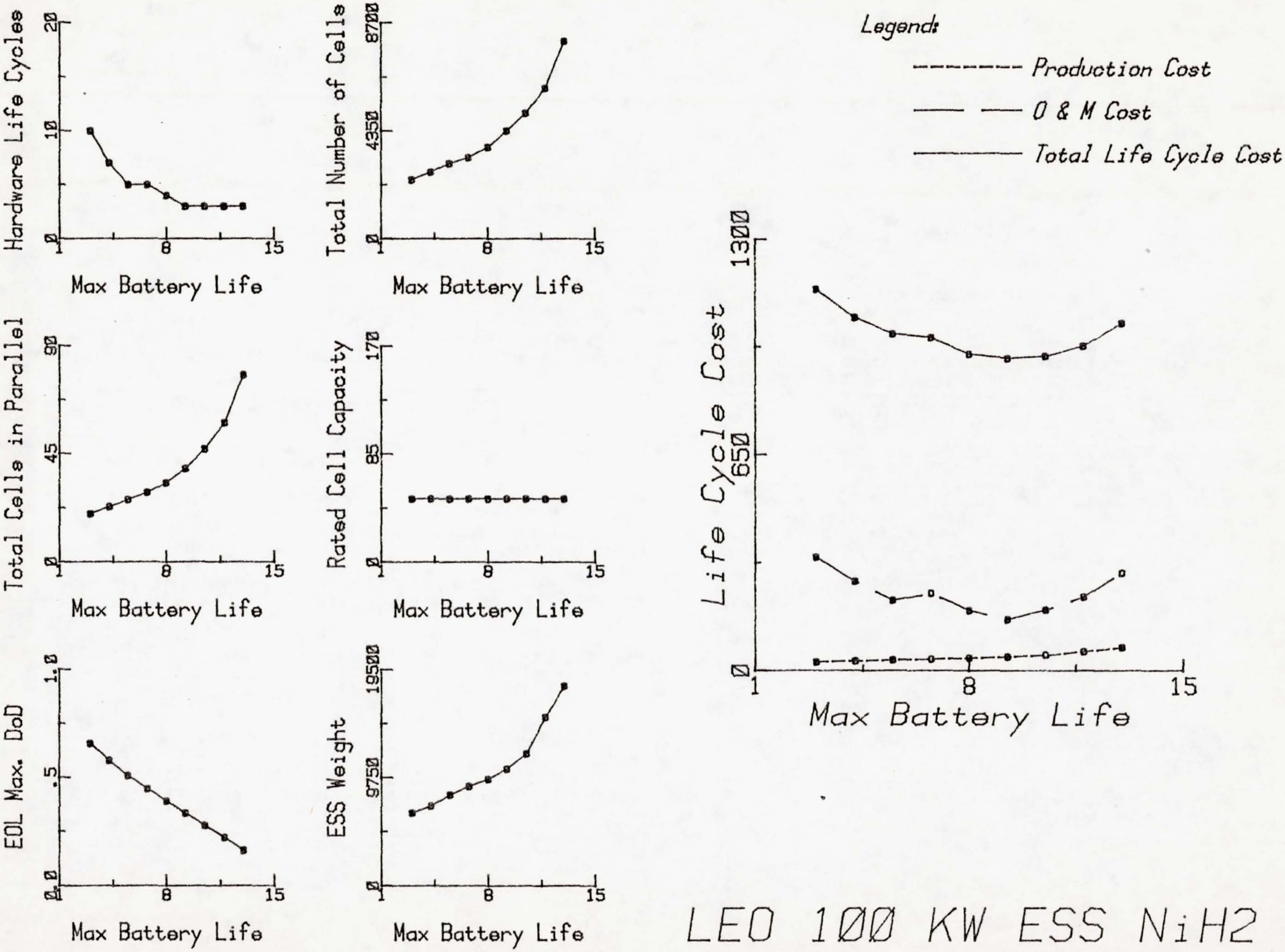

Exhibit 12c. Cell Life (Capacity Fixed) Continued

LEO 250KW ESS (NIH2)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	10	7	5	5	4	3	3	3	3
Maximum Battery Life (Yr)	3.000	4.250	5.500	6.750	8.000	9.250	10.500	11.750	13.000
Rated Cell Capacity (AH)	50	50	50	50	50	50	50	50	50
Maximum Depth of Discharge	.657	.577	.508	.447	.390	.333	.277	.220	.162
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	47.257	41.351	36.182	32.615	28.240	23.630	19.962	16.081	11.937
Minimum Voltage (V)	1.083	1.101	1.108	1.147	1.156	1.152	1.192	1.233	1.274
Recharge Fraction	1.080	1.073	1.072	1.071	1.071	1.072	1.072	1.072	1.072
Charge Current (A)	35.047	30.468	26.620	23.993	20.775	17.385	14.686	11.831	8.783
Charge Voltage (V)	1.708	1.703	1.713	1.673	1.678	1.699	1.673	1.651	1.632
Watt-Hour Efficiency	.587	.602	.604	.640	.643	.633	.665	.697	.728
PHYSICAL CHARACTERISTICS									
Total Number of Cells	5831	6608	7488	8023	9184	10976	12644	15120	19788
Number of Parallel Batteries	49	56	64	71	82	98	116	144	194
Number of Modules per Battery	5	5	5	5	4	4	4	4	4
Battery Cell Weight (Kg)	1.134	1.134	1.134	1.134	1.134	1.134	1.134	1.134	1.134
Battery Cell Volume (Cm^3)	2020	2020	2020	2020	2020	2020	2020	2020	2020
ESS Weight (Kg)	15378	16905	18708	20006	24053	27737	30161	33937	45151
ESS Volume (M^3)	104.880	132.500	151.420	162.620	227.140	268.430	271.030	263.280	387.170
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	14.619	15.886	17.326	18.195	20.069	22.957	25.591	29.498	36.970
Production Cost	58.693	64.557	71.363	75.889	88.155	101.970	112.691	128.949	168.053
Operations & Maintenance Cost	809.698	635.628	508.756	556.522	435.644	380.638	444.823	543.329	721.798
ESS LIFE CYCLE COST	883.010	716.071	597.445	650.606	543.868	505.565	583.105	701.776	926.821
Solar Array Cost	1568.177	1545.877	1540.730	1469.798	1462.666	1477.948	1427.738	1371.274	1327.530
Thermal Control Cost	28.509	27.623	28.251	24.546	24.855	26.608	24.204	22.095	20.440
Power Conditioning Cost	5.424	6.074	6.803	7.428	8.394	9.763	11.264	13.531	17.422
TOTAL LIFE CYCLE COST	2485.120	2295.645	2173.229	2152.378	2039.783	2019.884	2046.311	2108.676	2292.213

Exhibit 12d. Cell Life (Capacity Fixed)

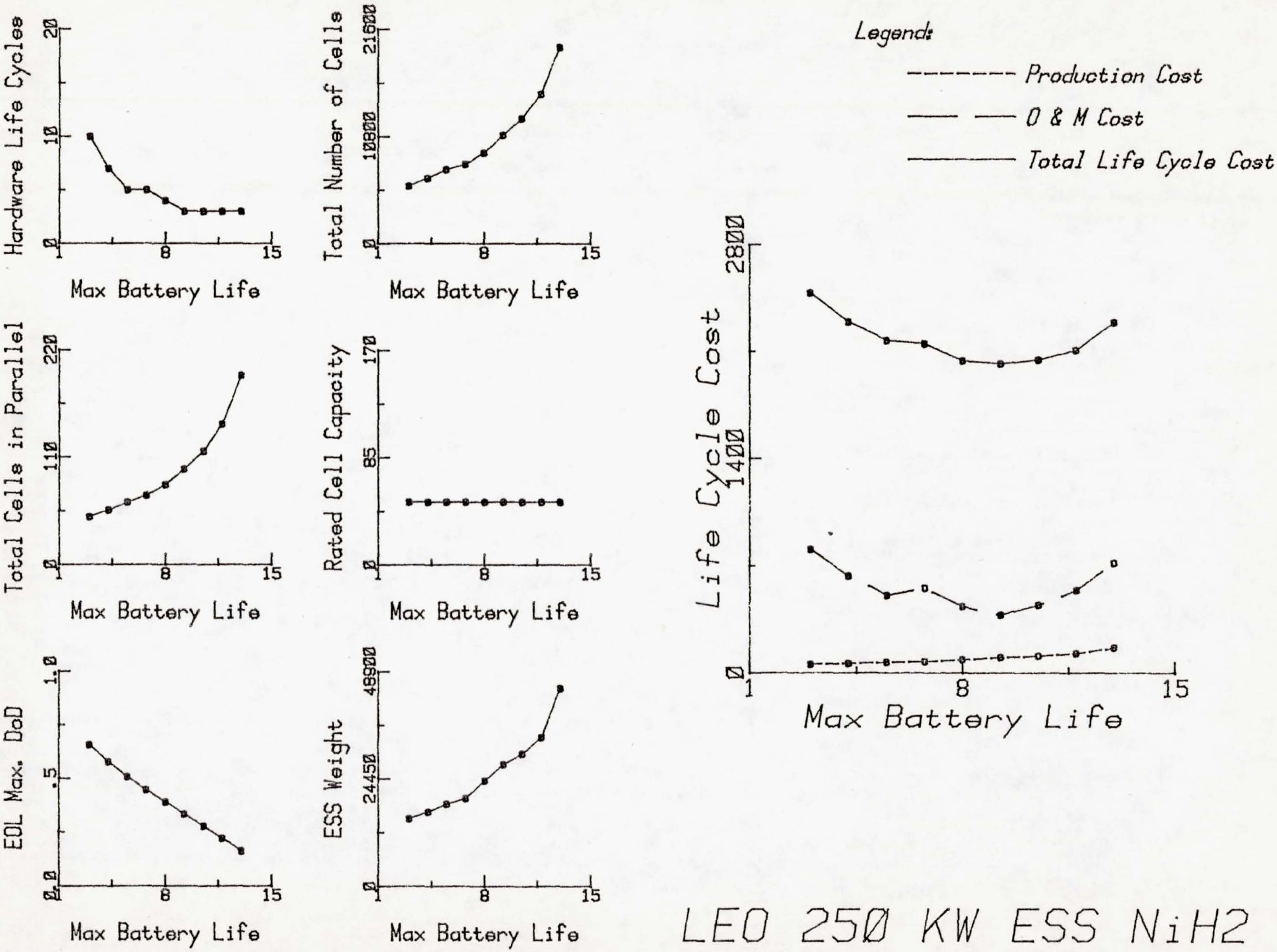

Exhibit 12d. Cell Life (Capacity Fixed) Continued

GEO 25KW ESS (NIH2)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	1	1	1	1	1	1	1	1	1
Maximum Battery Life (Yr)	3.000	4.250	5.500	6.750	8.000	9.250	10.500	11.750	13.000
Rated Cell Capacity (AH)	50	50	50	50	50	50	50	50	50
Maximum Depth of Discharge	.657	.577	.508	.447	.390	.333	.277	.220	.162
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	25.729	23.156	21.051	17.813	15.438	13.622	11.578	9.263	6.811
Minimum Voltage (V)	1.248	1.271	1.293	1.320	1.342	1.360	1.378	1.396	1.417
Recharge Fraction	1.118	1.073	1.072	1.071	1.071	1.072	1.072	1.072	1.072
Charge Current (A)	1.495	1.292	1.173	.992	.860	.759	.645	.516	.379
Charge Voltage (V)	1.474	1.470	1.469	1.467	1.465	1.464	1.463	1.462	1.461
Watt-Hour Efficiency	.757	.805	.821	.840	.854	.867	.879	.891	.905
PHYSICAL CHARACTERISTICS									
Total Number of Cells	936	1020	1100	1274	1440	1615	1880	2325	3094
Number of Parallel Batteries	9	10	11	13	15	17	20	25	34
Number of Modules per Battery	4	4	4	4	4	4	4	4	4
Battery Cell Weight (Kg)	1.134	1.134	1.134	1.134	1.134	1.134	1.134	1.134	1.134
Battery Cell Volume (Cm^3)	2020	2020	2020	2020	2020	2020	2020	2020	2020
ESS Weight (Kg)	2412	2351	2737	3189	3498	3806	4447	5994	6978
ESS Volume (M^3)	14.461	10.122	17.384	29.965	30.973	26.076	44.948	59.931	74.913
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	8.582	8.772	9.060	9.579	10.043	10.522	11.264	12.551	14.492
Production Cost	40.312	39.806	45.250	51.912	56.640	61.383	70.888	93.119	112.511
Operations & Maintenance Cost	.500	.500	.500	.500	.500	.500	.500	.500	.500
ESS LIFE CYCLE COST	49.394	49.078	54.810	61.991	67.183	72.405	82.652	106.170	127.503
Solar Array Cost	11.522	10.958	10.764	10.577	10.395	10.302	10.210	10.116	9.933
Thermal Control Cost	5.743	5.674	5.609	5.531	5.470	5.423	5.376	5.331	5.279
Power Conditioning Cost	1.289	1.409	1.528	1.761	1.988	2.210	2.537	3.065	3.979
TOTAL LIFE CYCLE COST	67.948	67.119	72.711	79.860	85.036	90.340	100.775	124.682	146.694

Exhibit 12e. Cell Life (Capacity Fixed)

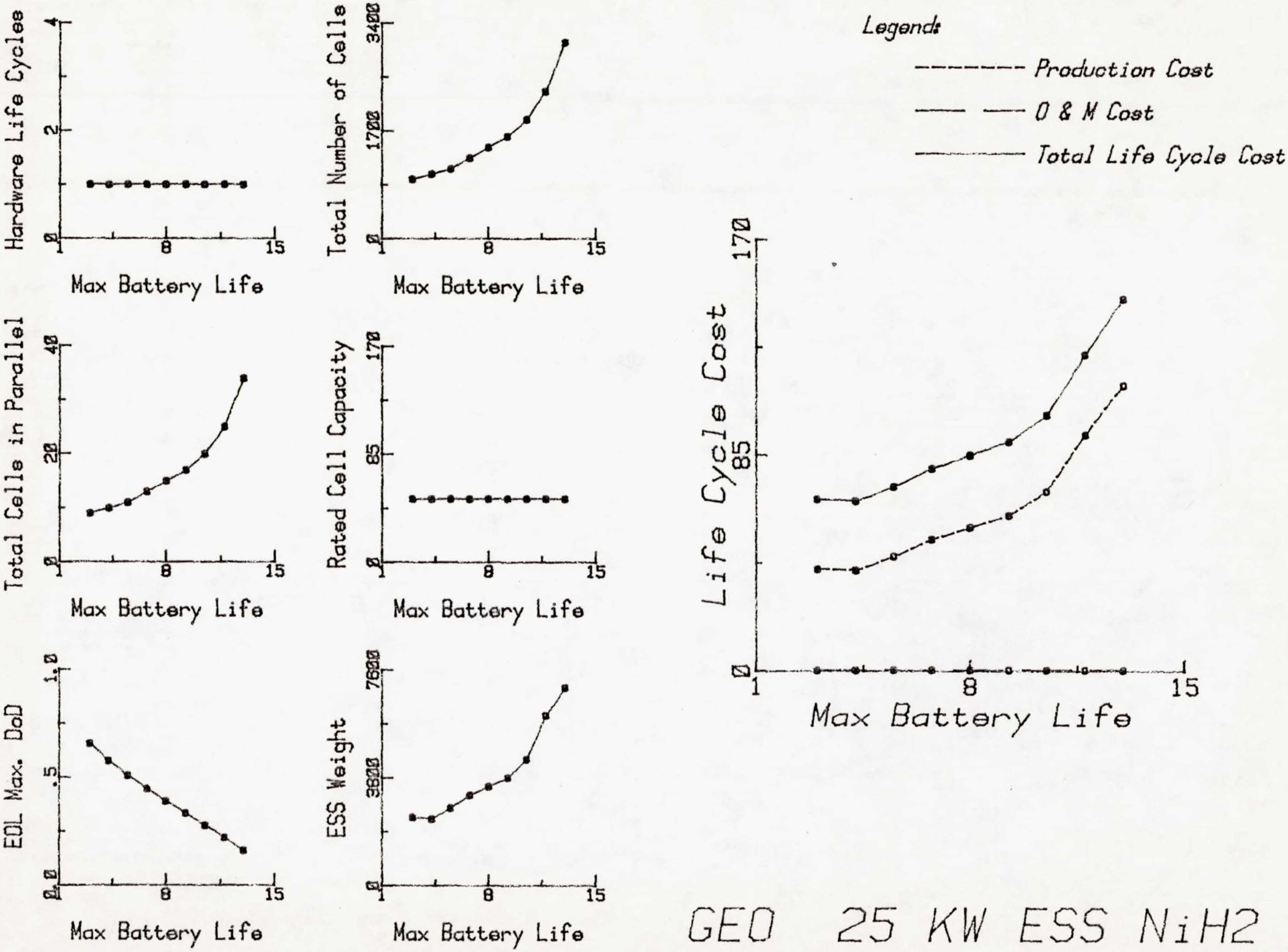

Exhibit 12e. Cell Life (Capacity Fixed) Continued

LEO 25KW ESS (NIH2)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	4	4	4	4	4	4	4	4	4
Maximum Battery Life (Yr)	7.260	7.785	7.786	8.661	10.468	11.593	12.359	12.895	13.295
Rated Cell Capacity (AH)	20	50	80	110	140	170	200	230	260
Maximum Depth of Discharge	.424	.400	.400	.360	.278	.227	.192	.167	.147
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	12.188	28.946	46.313	57.892	57.892	57.892	57.892	57.892	57.892
Minimum Voltage (V)	1.136	1.150	1.150	1.172	1.221	1.256	1.279	1.296	1.312
Recharge Fraction	1.072	1.072	1.071	1.072	1.072	1.072	1.072	1.072	1.072
Charge Current (A)	8.967	21.296	34.070	42.593	42.593	42.593	42.593	42.593	42.593
Charge Voltage (V)	1.697	1.683	1.683	1.663	1.632	1.616	1.607	1.601	1.595
Watt-Hour Efficiency	.624	.638	.638	.658	.698	.725	.742	.755	.768
PHYSICAL CHARACTERISTICS									
Total Number of Cells	2166	904	565	440	424	412	404	400	396
Number of Parallel Batteries	19	8	5	4	4	4	4	4	4
Number of Modules per Battery	5	5	5	4	4	4	4	4	4
Battery Cell Weight (Kg)	.454	1.134	1.814	2.495	3.175	3.856	4.536	5.216	5.897
Battery Cell Volume (Cm^3)	1547	2020	3764	4128	4492	4857	5221	5586	5951
ESS Weight (Kg)	3088	2178	2083	2134	2501	2864	3233	3619	3996
ESS Volume (M^3)	44.948	18.068	16.730	7.817	7.817	8.598	13.288	15.633	14.070
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	10.533	8.998	8.602	8.575	9.009	9.431	9.854	10.293	10.717
Production Cost	19.006	12.593	11.889	11.939	13.171	14.390	15.632	16.935	18.209
Operations & Maintenance Cost	110.691	55.824	42.185	34.841	37.663	40.435	43.240	46.178	49.054
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ESS LIFE CYCLE COST	140.230	77.415	62.676	55.355	59.843	64.256	68.726	73.406	77.980
Solar Array Cost	235.692	232.476	232.454	225.348	215.408	208.934	204.743	202.489	200.218
Thermal Control Cost	7.343	7.223	7.221	7.030	6.753	6.612	6.527	6.478	6.431
Power Conditioning Cost	2.429	1.166	.783	.648	.648	.648	.648	.648	.648
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TOTAL LIFE CYCLE COST	385.694	318.280	303.134	288.381	282.652	280.450	280.644	283.021	285.277

Exhibit 13a. Rated Cell Capacity

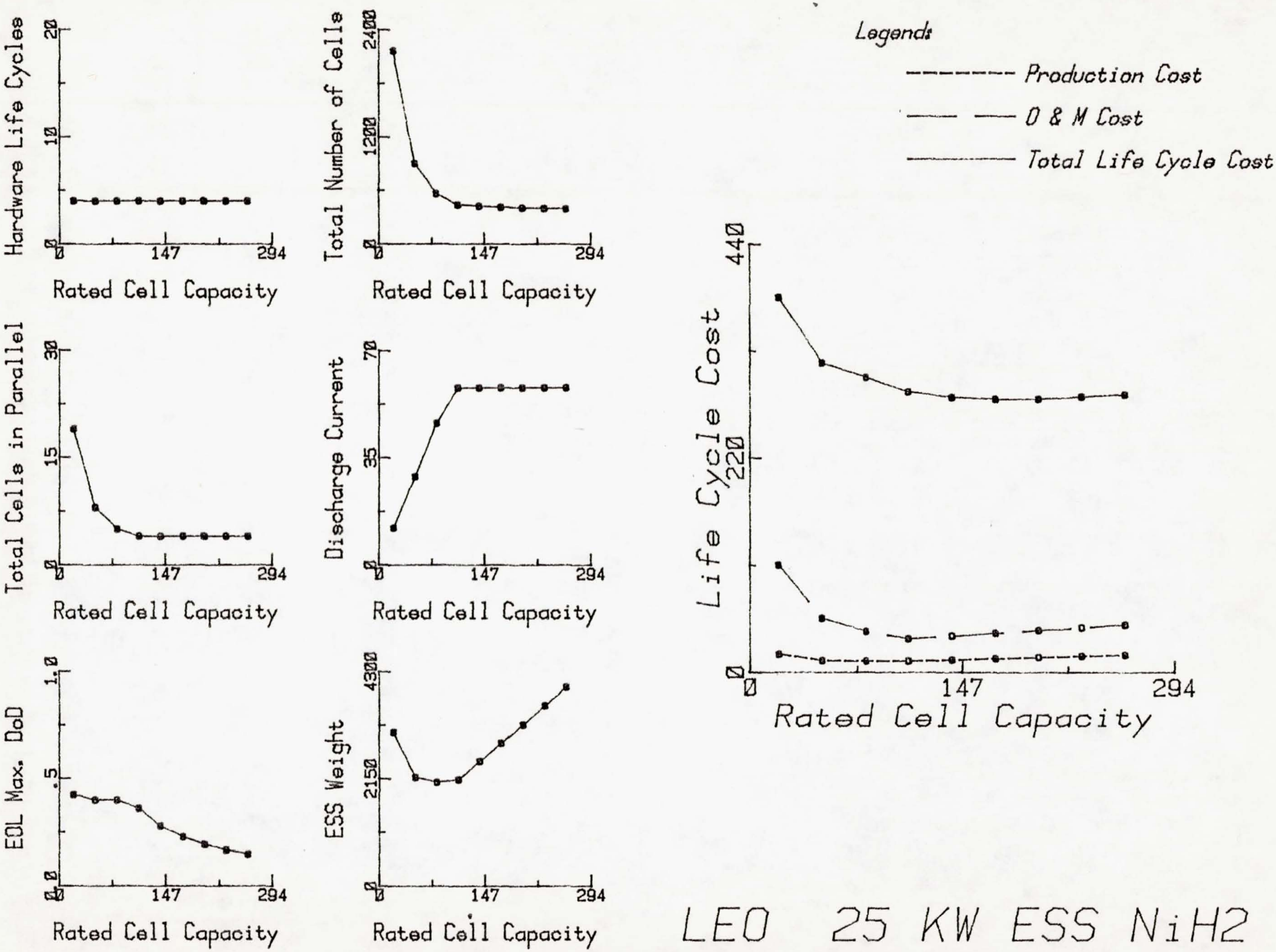

Exhibit 13a. Rated Cell Capacity (Continued)

LEO 50KW ESS (NIH2)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	4	4	4	4	4	4	4	4	4
Maximum Battery Life (Yr)	6.968	7.117	7.786	7.399	8.246	8.353	7.786	9.037	9.968
Rated Cell Capacity (AH)	20	50	80	110	140	170	200	230	260
Maximum Depth of Discharge	.437	.430	.400	.417	.378	.374	.400	.343	.301
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	12.517	30.875	46.313	66.160	77.188	92.625	115.780	115.780	115.780
Minimum Voltage (V)	1.127	1.131	1.150	1.139	1.162	1.164	1.150	1.181	1.204
Recharge Fraction	1.071	1.072	1.071	1.071	1.071	1.072	1.071	1.071	1.071
Charge Current (A)	9.209	22.715	34.070	48.670	56.784	68.145	85.173	85.173	85.173
Charge Voltage (V)	1.706	1.701	1.683	1.693	1.672	1.670	1.683	1.656	1.639
Watt-Hour Efficiency	.617	.621	.638	.628	.648	.651	.638	.666	.686
PHYSICAL CHARACTERISTICS									
Total Number of Cells	4255	1710	1130	798	666	555	452	440	428
Number of Parallel Batteries	37	15	10	7	6	5	4	4	4
Number of Modules per Battery	5	5	5	5	4	4	5	4	4
Battery Cell Weight (Kg)	.454	1.134	1.814	2.495	3.175	3.856	4.536	5.216	5.897
Battery Cell Volume (Cm^3)	1547	2020	3764	4128	4492	4857	5221	5586	5951
ESS Weight (Kg)	5677	4488	4165	3988	4088	4093	3977	4289	4623
ESS Volume (M^3)	77.433	36.137	33.459	28.888	23.361	21.376	14.070	17.197	14.851
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	13.548	10.788	10.294	9.854	9.883	9.812	9.598	9.948	10.301
Production Cost	30.107	20.471	19.160	18.204	18.432	18.341	17.819	18.902	20.035
Operations & Maintenance Cost	206.727	99.444	77.339	63.119	54.658	50.926	49.789	49.192	51.809
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ESS LIFE CYCLE COST	250.382	130.703	106.793	91.177	82.973	79.079	77.206	78.042	82.145
Solar Array Cost	415.806	412.037	405.569	410.407	397.720	397.267	405.569	391.688	380.074
Thermal Control Cost	9.647	9.545	9.242	9.425	9.017	8.984	9.243	8.753	8.436
Power Conditioning Cost	4.274	1.988	1.409	1.042	.914	.783	.648	.648	.648
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TOTAL LIFE CYCLE COST	680.109	554.273	523.013	512.051	490.624	486.113	492.666	479.131	471.303

Exhibit 13b. Rated Cell Capacity

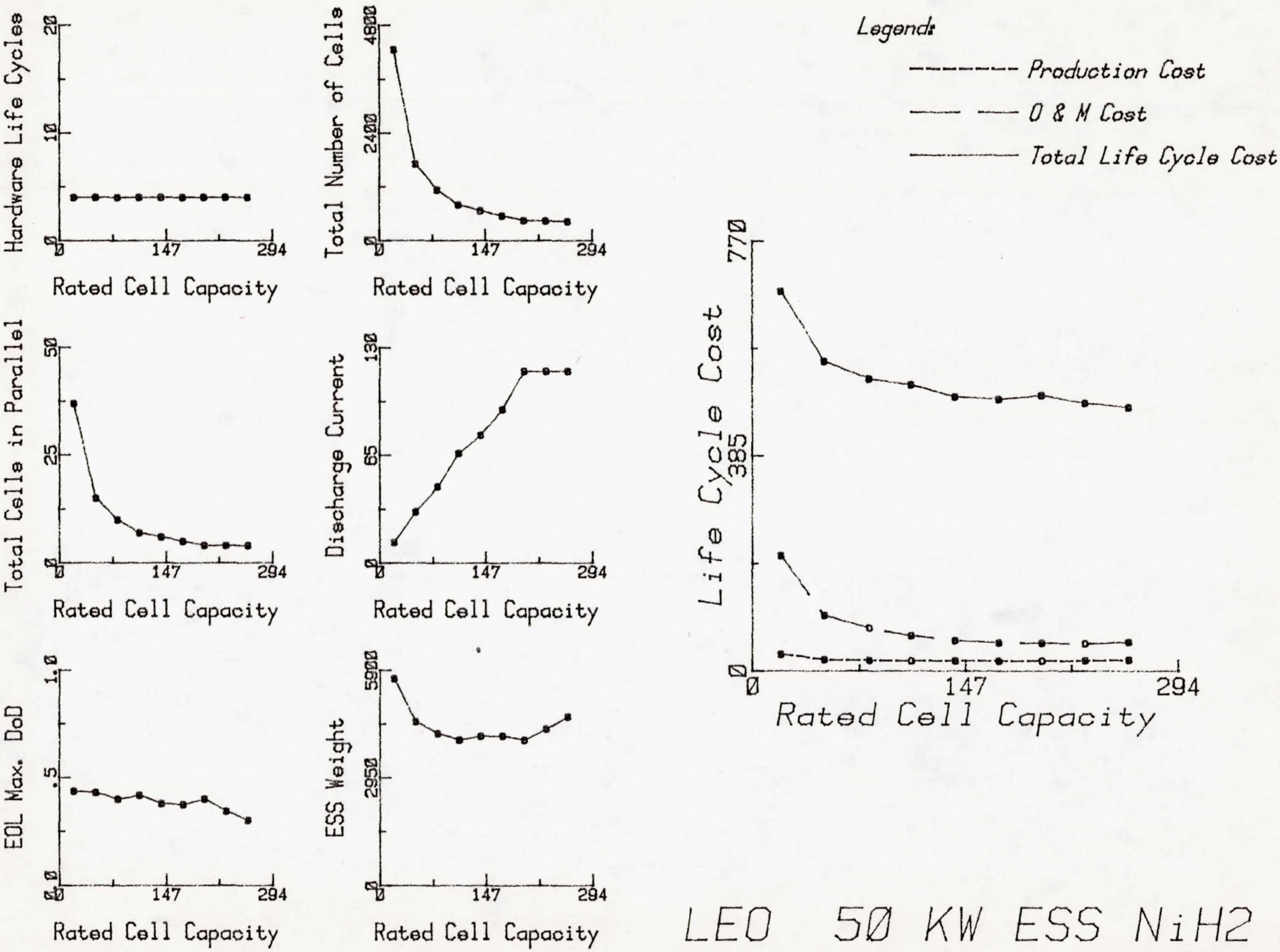

Exhibit 13b. Rated Cell Capacity (Continued)

LEO 100KW ESS (NIH2)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	4	4	4	4	4	4	4	4	4
Maximum Battery Life (Yr)	6.968	7.117	7.260	7.399	7.399	7.330	7.786	7.847	7.532
Rated Cell Capacity (AH)	20	50	80	110	140	170	200	230	260
Maximum Depth of Discharge	.437	.430	.424	.417	.417	.421	.400	.397	.411
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	12.517	30.875	48.750	66.160	84.204	102.920	115.780	132.320	154.380
Minimum Voltage (V)	1.127	1.131	1.136	1.139	1.139	1.137	1.150	1.152	1.143
Recharge Fraction	1.071	1.072	1.072	1.071	1.071	1.071	1.071	1.071	1.072
Charge Current (A)	9.209	22.715	35.866	48.670	61.944	75.713	85.173	97.340	113.580
Charge Voltage (V)	1.706	1.701	1.697	1.693	1.693	1.695	1.683	1.681	1.690
Watt-Hour Efficiency	.617	.621	.625	.628	.628	.626	.638	.639	.631
PHYSICAL CHARACTERISTICS									
Total Number of Cells	8510	3420	2166	1596	1254	1026	904	784	678
Number of Parallel Batteries	74	30	19	14	11	9	8	7	6
Number of Modules per Battery	5	5	5	5	5	5	5	4	5
Battery Cell Weight (Kg)	.454	1.134	1.814	2.495	3.175	3.856	4.536	5.216	5.897
Battery Cell Volume (Cm^3)	1547	2020	3764	4128	4492	4857	5221	5586	5951
ESS Weight (Kg)	11352	8974	9262	7976	8421	8415	7952	7818	7741
ESS Volume (M^3)	154.870	72.273	86.664	57.776	42.660	39.035	34.283	25.678	27.423
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	19.705	14.591	13.463	12.884	12.600	12.360	12.402	12.231	12.057
Production Cost	55.262	36.164	35.073	31.691	32.147	31.782	30.933	30.419	30.012
Operations & Maintenance Cost	405.275	191.317	141.494	118.861	105.350	95.917	92.743	81.813	82.498
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ESS LIFE CYCLE COST	480.242	242.072	190.030	163.436	150.097	140.059	136.078	124.463	124.567
Solar Array Cost	725.476	718.908	717.437	716.048	716.048	716.743	707.614	702.074	709.909
Thermal Control Cost	14.092	13.887	13.765	13.649	13.649	13.706	13.286	13.168	13.476
Power Conditioning Cost	7.694	3.578	2.429	1.875	1.528	1.289	1.166	1.042	.914
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TOTAL LIFE CYCLE COST	1227.504	978.445	923.661	895.008	881.322	871.797	858.144	840.747	848.866

Exhibit 13c. Rated Cell Capacity

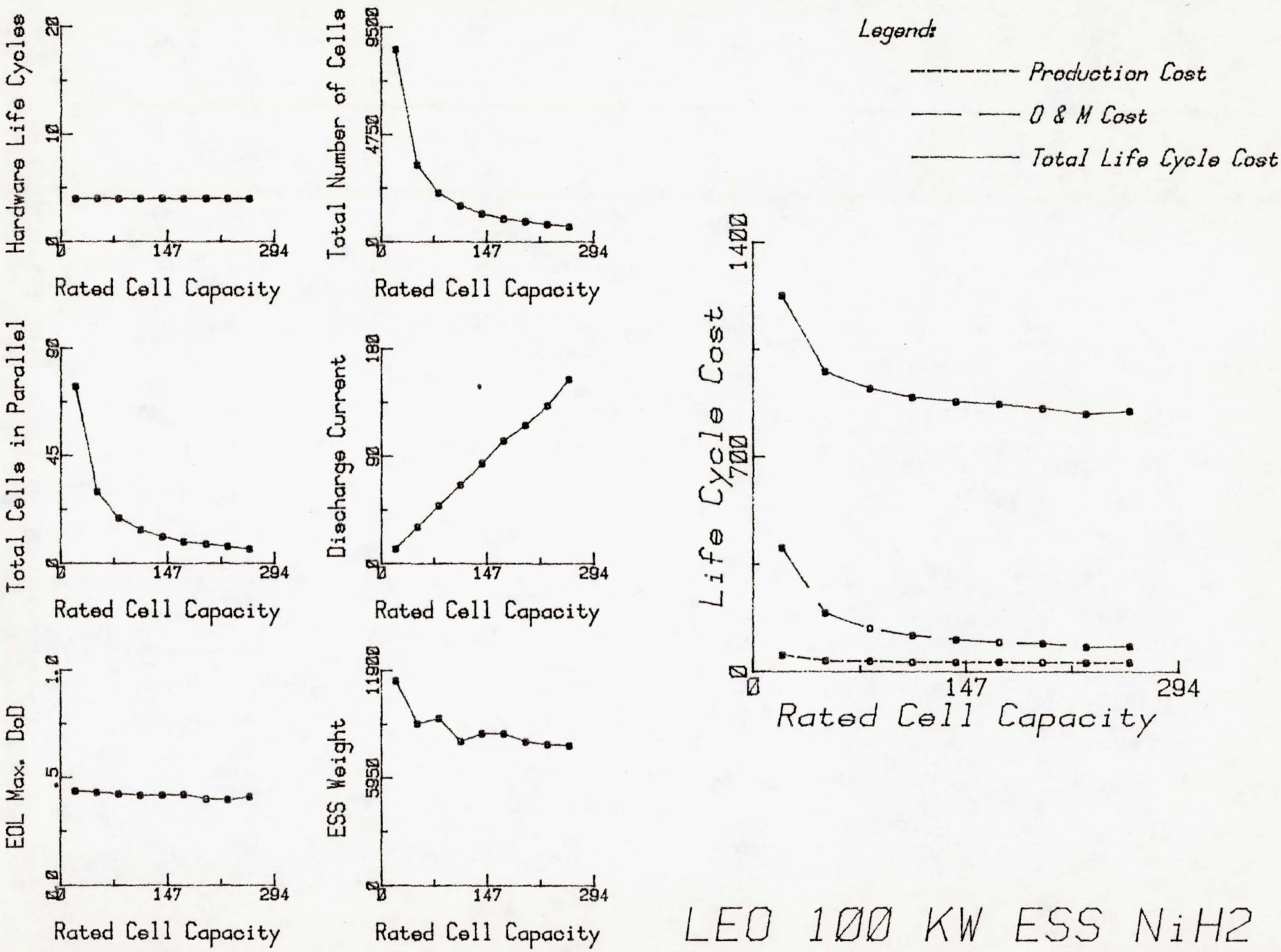

Exhibit 13c. Rated Cell Capacity (Continued)

LEO 250KW ESS (NIH2)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	4	4	4	4	4	4	4	4	4
Maximum Battery Life (Yr)	6.906	6.968	6.906	7.088	7.204	7.087	7.260	6.906	7.161
Rated Cell Capacity (AH)	20	50	80	110	140	170	200	230	260
Maximum Depth of Discharge	.440	.437	.440	.432	.426	.432	.424	.440	.414
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	12.585	31.292	50.340	68.107	85.764	105.260	121.880	144.730	154.380
Minimum Voltage (V)	1.125	1.127	1.125	1.131	1.134	1.131	1.136	1.125	1.136
Recharge Fraction	1.071	1.072	1.071	1.071	1.071	1.072	1.072	1.071	1.072
Charge Current (A)	9.259	23.022	37.033	50.103	63.092	77.441	89.668	106.470	113.580
Charge Voltage (V)	1.708	1.706	1.708	1.702	1.699	1.702	1.697	1.708	1.699
Watt-Hour Efficiency	.615	.617	.615	.620	.623	.620	.624	.615	.624
PHYSICAL CHARACTERISTICS									
Total Number of Cells	21160	8510	5290	3876	3078	2508	2166	1840	1710
Number of Parallel Batteries	184	74	46	34	27	22	19	16	15
Number of Modules per Battery	5	5	5	5	5	5	5	5	5
Battery Cell Weight (Kg)	.454	1.134	1.814	2.495	3.175	3.856	4.536	5.216	5.897
Battery Cell Volume (Cm^3)	1547	2020	3764	4128	4492	4857	5221	5586	5951
ESS Weight (Kg)	24148	22771	20858	20103	20029	20184	20453	18850	20134
ESS Volume (M^3)	356.200	189.280	179.160	144.440	115.550	89.578	86.664	72.991	68.566
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	26.932	19.059	16.954	16.117	15.722	15.311	15.256	14.821	15.211
Production Cost	123.409	83.337	74.814	71.439	70.408	69.797	70.210	66.043	69.474
Operations & Maintenance Cost	1003.459	461.213	332.121	277.784	247.194	223.002	211.353	195.002	196.165
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ESS LIFE CYCLE COST	1153.800	563.609	423.889	365.340	333.324	308.110	296.819	275.866	280.850
Solar Array Cost	1515.578	1514.082	1515.476	1500.868	1498.481	1500.970	1497.423	1515.476	1498.754
Thermal Control Cost	27.579	27.435	27.572	26.972	26.728	26.977	26.617	27.572	26.777
Power Conditioning Cost	16.657	7.694	5.141	3.979	3.272	2.750	2.429	2.100	1.988
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TOTAL LIFE CYCLE COST	2713.614	2112.820	1972.078	1897.159	1861.805	1838.807	1823.288	1821.014	1808.369

Exhibit 13d. Rated Cell Capacity

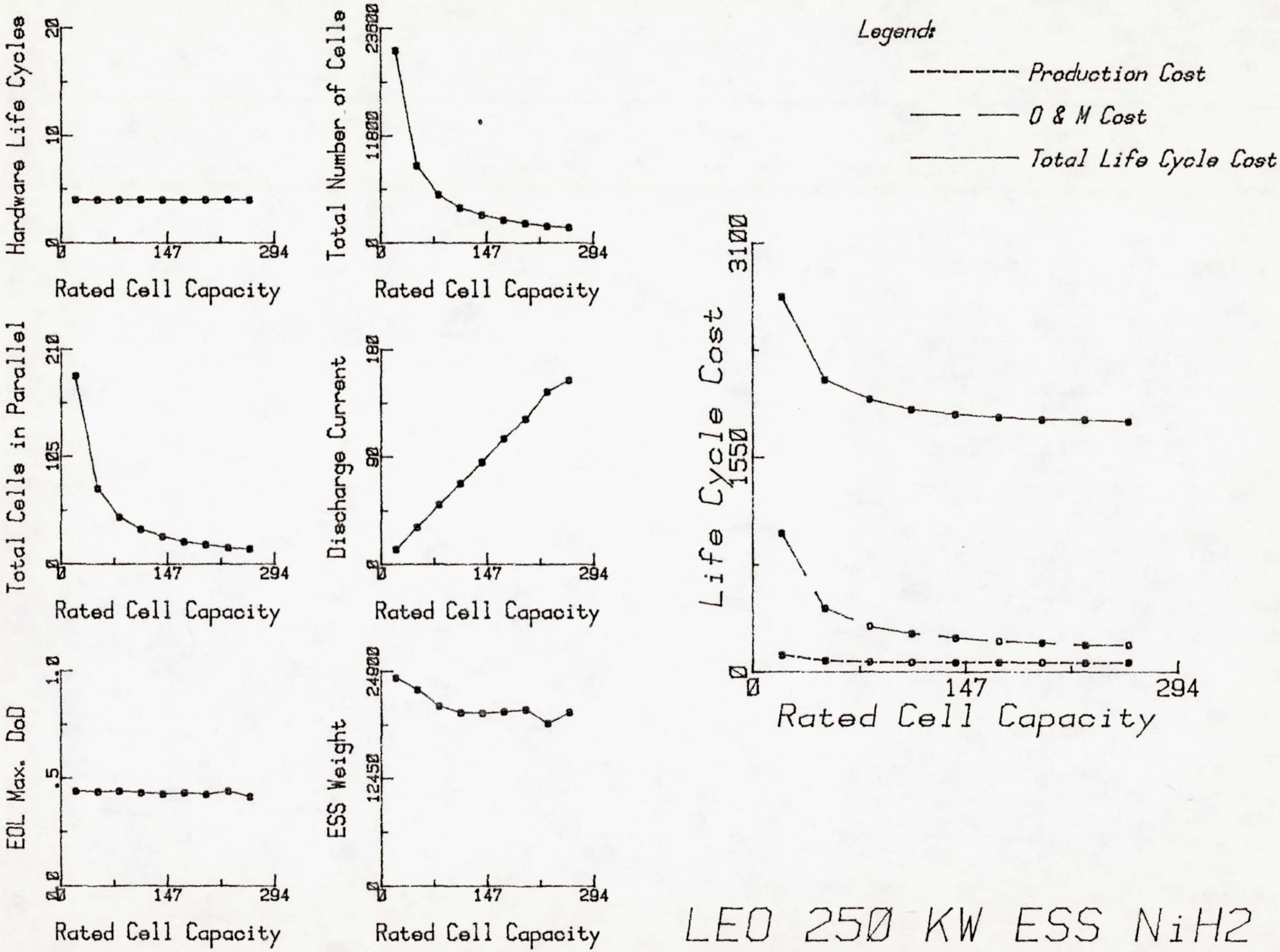

Exhibit 13d. Rated Cell Capacity (Continued)

GEO 25KW ESS (NiH2)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	1	1	1	1	1	1	1	1	1
Maximum Battery Life (Yr)	1.049	1.304	2.586	3.526	5.868	7.718	9.045	10.036	10.798
Rated Cell Capacity (AH)	20	50	80	110	140	170	200	230	260
Maximum Depth of Discharge	.811	.787	.686	.623	.489	.403	.342	.298	.263
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	13.622	33.080	46.312	57.890	57.890	57.890	57.890	57.890	57.890
Minimum Voltage (V)	1.206	1.213	1.238	1.252	1.298	1.331	1.354	1.370	1.382
Recharge Fraction	1.604	1.375	1.145	1.093	1.071	1.072	1.071	1.072	1.072
Charge Current (A)	1.013	2.364	2.756	3.290	3.224	3.225	3.224	3.224	3.224
Charge Voltage (V)	1.493	1.489	1.477	1.473	1.468	1.466	1.465	1.464	1.463
Watt-Hour Efficiency	.564	.592	.732	.778	.825	.847	.863	.874	.881
PHYSICAL CHARACTERISTICS									
Total Number of Cells	1819	749	525	412	400	388	384	376	376
Number of Parallel Batteries	17	7	5	4	4	4	4	4	4
Number of Modules per Battery	4	4	4	4	4	4	4	4	4
Battery Cell Weight (Kg)	.454	1.134	1.814	2.495	3.175	3.856	4.536	5.216	5.897
Battery Cell Volume (Cm^3)	1547	2020	3764	4128	4492	4857	5221	5586	5951
ESS Weight (Kg)	2272	1796	1888	1969	2333	2673	3046	3379	3769
ESS Volume (M^3)	23.705	15.816	15.800	8.598	8.598	8.598	14.070	14.070	14.070
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	9.131	7.954	7.890	7.901	8.307	8.675	9.078	9.426	9.837
Production Cost	40.943	31.405	32.495	33.559	38.874	43.838	49.296	54.161	59.870
Operations & Maintenance Cost	.500	.500	.500	.500	.500	.500	.500	.500	.500
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ESS LIFE CYCLE COST	50.574	39.859	40.885	41.960	47.681	53.013	58.874	64.087	70.207
Solar Array Cost	14.520	14.034	11.855	11.221	10.756	10.486	10.389	10.209	10.207
Thermal Control Cost	5.858	5.844	5.775	5.730	5.597	5.502	5.442	5.395	5.368
Power Conditioning Cost	2.210	1.042	.783	.648	.648	.648	.648	.648	.648
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TOTAL LIFE CYCLE COST	73.162	60.779	59.298	59.559	64.682	69.649	75.353	80.339	86.430

Exhibit 13e. Rated Cell Capacity

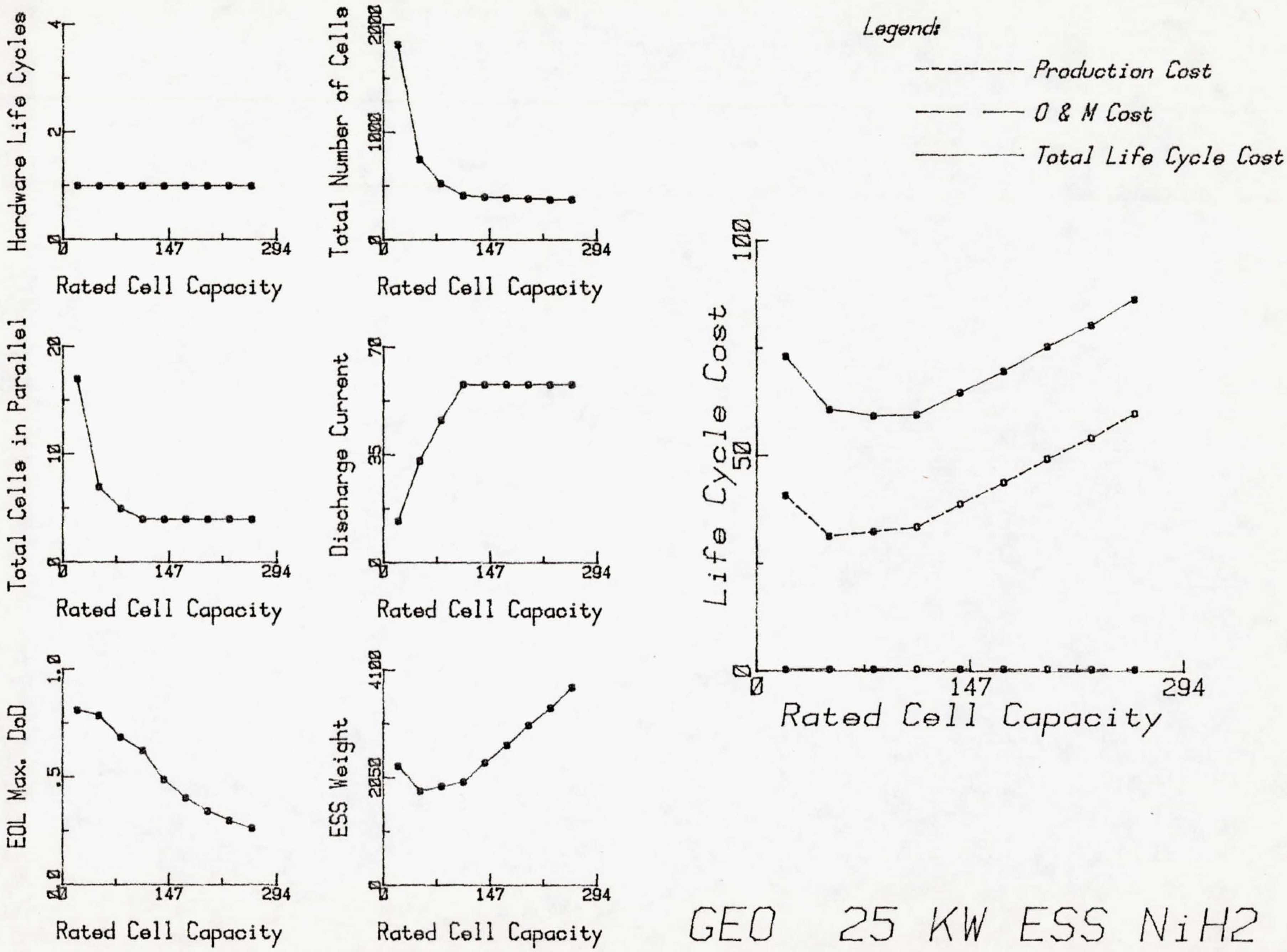

Exhibit 13e. Rated Cell Capacity (Continued)

LEO 25KW ESS (H1H2)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	3	4	5	6	7	8	9	10	11
Maximum Battery Life (Yr)	9.148	7.479	6.917	5.019	5.193	5.313	4.067	2.777	2.888
Rated Cell Capacity (AH)	40	35	30	25	25	25	25	20	20
Maximum Depth of Discharge	.338	.382	.440	.535	.525	.519	.525	.674	.665
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	19.298	19.298	19.298	19.298	19.298	19.298	19.298	19.298	19.298
Minimum Voltage (V)	1.149	1.149	1.152	1.112	1.135	1.151	1.136	1.071	1.088
Recharge Fraction	1.071	1.072	1.072	1.071	1.071	1.071	1.072	1.081	1.081
Charge Current (A)	14.197	14.198	14.198	14.197	14.197	14.197	14.198	14.329	14.320
Charge Voltage (V)	1.702	1.689	1.669	1.698	1.667	1.646	1.666	1.725	1.699
Watt-Hour Efficiency	.630	.635	.644	.611	.635	.653	.636	.574	.593
PHYSICAL CHARACTERISTICS									
Total Number of Cells	1356	1356	1344	1392	1368	1344	1368	1452	1428
Number of Parallel Batteries	12	12	12	12	12	12	12	12	12
Number of Modules per Battery	5	5	4	5	5	4	5	5	5
Battery Cell Weight (Kg)	.907	.794	.680	.567	.567	.567	.567	.454	.454
Battery Cell Volume (Cm^3)	1853	1772	1695	1620	1620	1620	1620	1547	1547
ESS Weight (Kg)	2624	2384	2108	1950	1917	1867	1917	1767	1739
ESS Volume (M^3)	28.446	28.446	18.964	28.446	28.446	18.964	28.446	28.446	28.446
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	9.891	9.619	9.297	9.142	9.087	9.015	9.087	8.973	8.921
Production Cost	15.273	14.956	12.882	14.421	14.355	12.307	14.355	14.246	14.185
Operations & Maintenance Cost	57.496	77.411	79.629	115.591	135.264	126.652	175.000	192.749	212.014
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ESS LIFE CYCLE COST	82.660	101.986	101.808	139.154	158.706	147.974	198.442	215.968	235.120
Solar Array Cost	234.574	233.127	229.254	239.127	232.357	226.721	232.255	252.324	245.925
Thermal Control Cost	7.378	7.270	7.087	7.362	7.090	6.896	7.082	7.706	7.461
Power Conditioning Cost	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645
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TOTAL LIFE CYCLE COST	326.257	344.028	339.794	387.288	399.798	383.236	439.424	477.643	490.151

Exhibit 14a. Hardware Life Cycles (Capacity Variable)

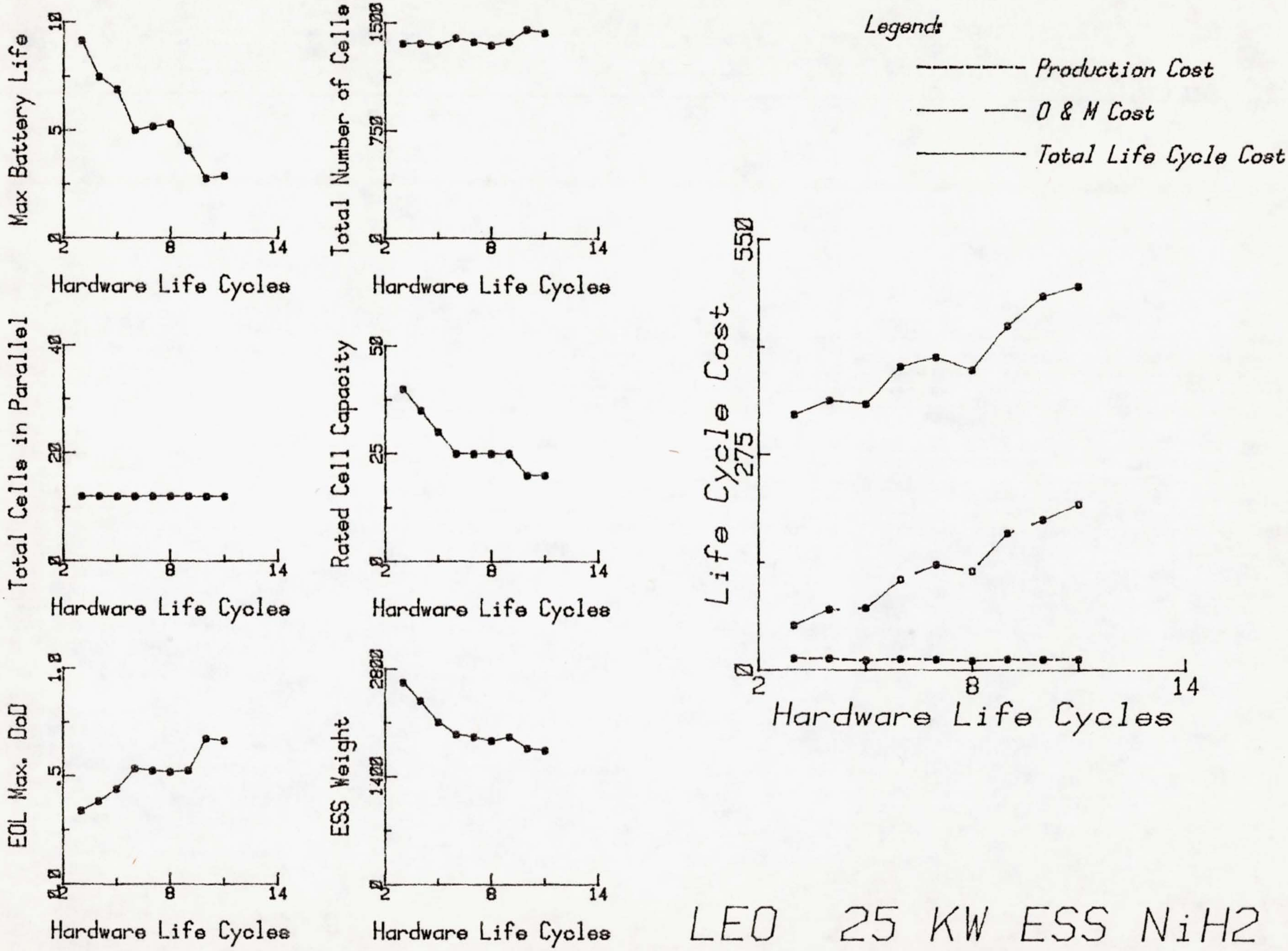

Exhibit 14a. Hardware Life Cycles (Capacity Variable) Continued

LEO 50KW ESS (NIH2)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	3	4	5	6	7	8	9	10	11
Maximum Battery Life (Yr)	9.148	7.532	5.911	5.020	4.434	4.065	4.199	2.765	2.889
Rated Cell Capacity (AH)	80	65	55	50	45	45	45	40	40
Maximum Depth of Discharge	.338	.411	.487	.535	.592	.590	.582	.675	.665
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	38.594	38.594	38.594	38.594	38.594	38.594	38.594	38.594	38.594
Minimum Voltage (V)	1.149	1.143	1.122	1.112	1.101	1.107	1.124	1.070	1.088
Recharge Fraction	1.072	1.072	1.072	1.071	1.074	1.074	1.073	1.082	1.081
Charge Current (A)	28.394	28.394	28.394	28.391	28.471	28.463	28.444	28.659	28.638
Charge Voltage (V)	1.702	1.690	1.698	1.698	1.697	1.689	1.666	1.726	1.699
Watt-Hour Efficiency	.630	.631	.617	.611	.604	.610	.629	.574	.593
PHYSICAL CHARACTERISTICS									
Total Number of Cells	1356	1356	1380	1392	1404	1404	1380	1452	1428
Number of Parallel Batteries	12	12	12	12	12	12	12	12	12
Number of Modules per Battery	5	5	5	5	5	5	5	5	5
Battery Cell Weight (Kg)	1.814	1.474	1.247	1.134	1.021	1.021	1.021	.907	.907
Battery Cell Volume (Cm^3)	3764	3582	3461	2020	1936	1936	1936	1853	1853
ESS Weight (Kg)	4868	4154	3739	3521	3301	3295	3238	3155	3099
ESS Volume (M^3)	42.660	42.660	44.692	28.446	28.446	28.446	28.446	28.446	28.446
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	11.173	10.456	10.046	9.832	9.615	9.614	9.543	9.488	9.421
Production Cost	21.739	19.952	19.841	17.301	16.586	16.573	16.368	16.134	15.937
Operations & Maintenance Cost	66.317	87.317	110.517	124.747	143.298	164.484	184.697	203.527	223.234
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ESS LIFE CYCLE COST	99.229	117.725	140.404	151.880	169.499	190.671	210.608	229.149	248.592
Solar Array Cost	409.273	406.875	414.334	417.170	420.802	419.115	408.527	440.457	429.049
Thermal Control Cost	9.557	9.339	9.510	9.524	9.560	9.431	8.989	10.228	9.722
Power Conditioning Cost	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645
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TOTAL LIFE CYCLE COST	519.704	535.584	565.893	580.219	601.506	620.862	629.769	681.479	689.008

Exhibit 14b. Hardware Life Cycles (Capacity Variable)

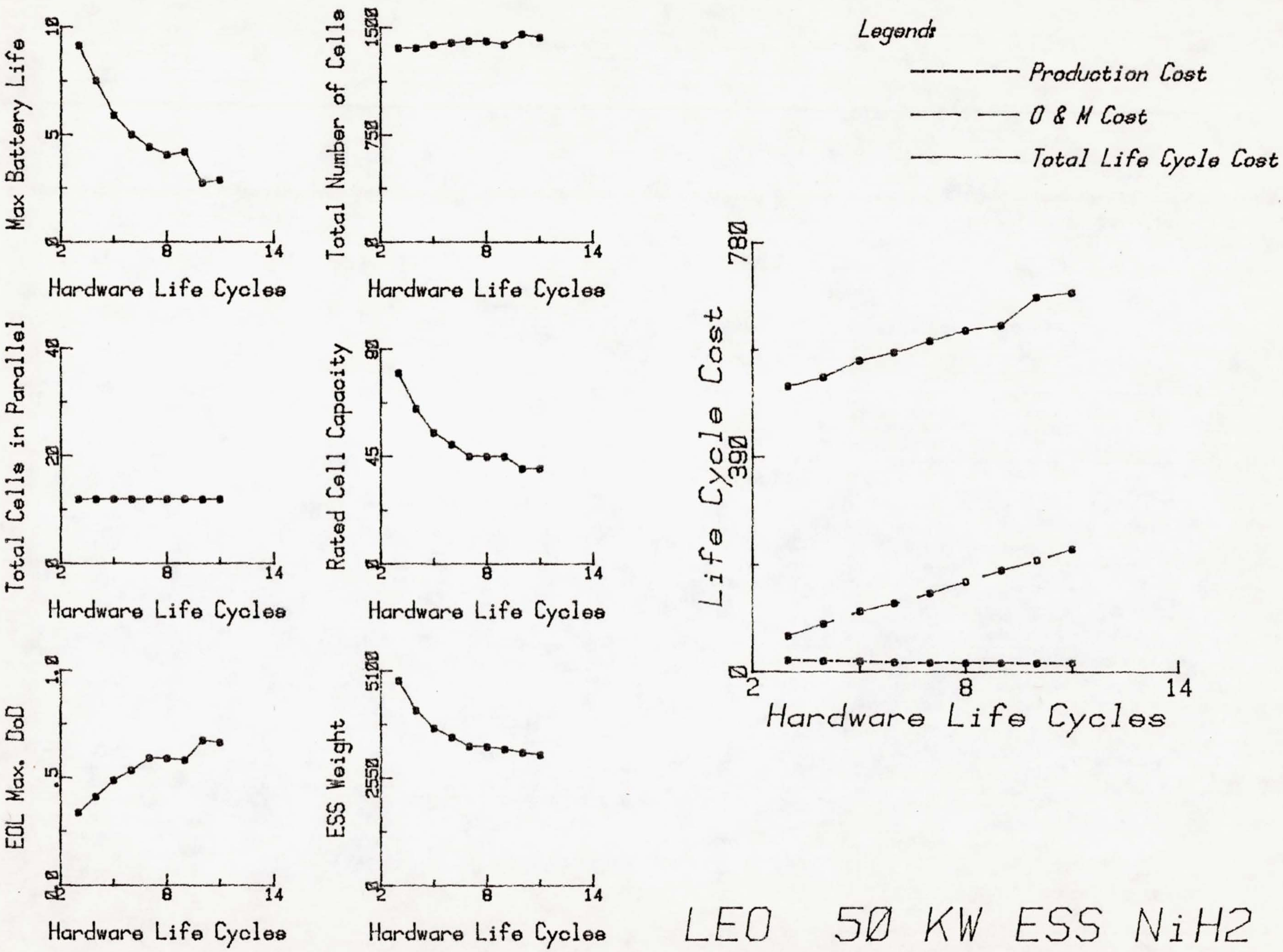

Exhibit 14b. Hardware Life Cycles (Capacity Variable) Continued

LEO 100KW ESS (NiH2)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	3	4	5	6	7	8	9	10	11
Maximum Battery Life (Yr)	9.148	7.117	5.911	5.020	4.232	3.684	3.472	2.752	2.888
Rated Cell Capacity (AH)	160	125	110	100	90	90	85	85	80
Maximum Depth of Discharge	.338	.430	.487	.535	.595	.595	.627	.635	.665
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	77.189	77.189	77.189	77.189	77.189	77.189	77.189	77.189	77.189
Minimum Voltage (V)	1.149	1.131	1.122	1.112	1.095	1.094	1.093	1.077	1.088
Recharge Fraction	1.071	1.071	1.071	1.071	1.075	1.075	1.078	1.078	1.081
Charge Current (A)	56.784	56.784	56.784	56.784	56.953	56.953	57.107	57.149	57.276
Charge Voltage (V)	1.702	1.701	1.698	1.698	1.706	1.707	1.699	1.723	1.699
Watt-Hour Efficiency	.630	.621	.617	.611	.597	.597	.597	.580	.593
PHYSICAL CHARACTERISTICS									
Total Number of Cells	1356	1368	1380	1392	1416	1416	1416	1440	1428
Number of Parallel Batteries	12	12	12	12	12	12	12	12	12
Number of Modules per Battery	5	5	5	5	5	5	5	5	5
Battery Cell Weight (Kg)	3.629	2.835	2.495	2.268	2.041	2.041	1.928	1.928	1.814
Battery Cell Volume (Cm^3)	4735	4310	4128	4007	3886	3886	3825	3825	3764
ESS Weight (Kg)	9358	7765	7098	6663	6275	6276	6022	6135	5816
ESS Volume (M^3)	42.660	42.660	44.692	44.692	44.692	44.692	44.692	44.692	44.692
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	13.986	12.520	11.912	11.514	11.159	11.160	10.928	11.026	10.741
Production Cost	36.031	30.740	28.539	27.103	25.824	25.827	24.990	25.354	24.315
Operations & Maintenance Cost	85.994	108.515	132.531	156.168	178.258	205.184	227.341	255.482	275.022
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ESS LIFE CYCLE COST	136.011	151.775	172.982	194.785	215.241	242.171	263.259	291.862	310.078
Solar Array Cost	714.044	718.867	722.867	727.879	742.420	742.744	741.529	760.600	748.573
Thermal Control Cost	13.910	13.885	13.817	13.847	14.272	14.301	14.101	15.039	14.242
Power Conditioning Cost	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645
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TOTAL LIFE CYCLE COST	865.610	886.172	911.311	938.156	973.578	1000.861	1020.534	1069.146	1074.538

Exhibit 14c. Hardware Life Cycles (Capacity Variable)

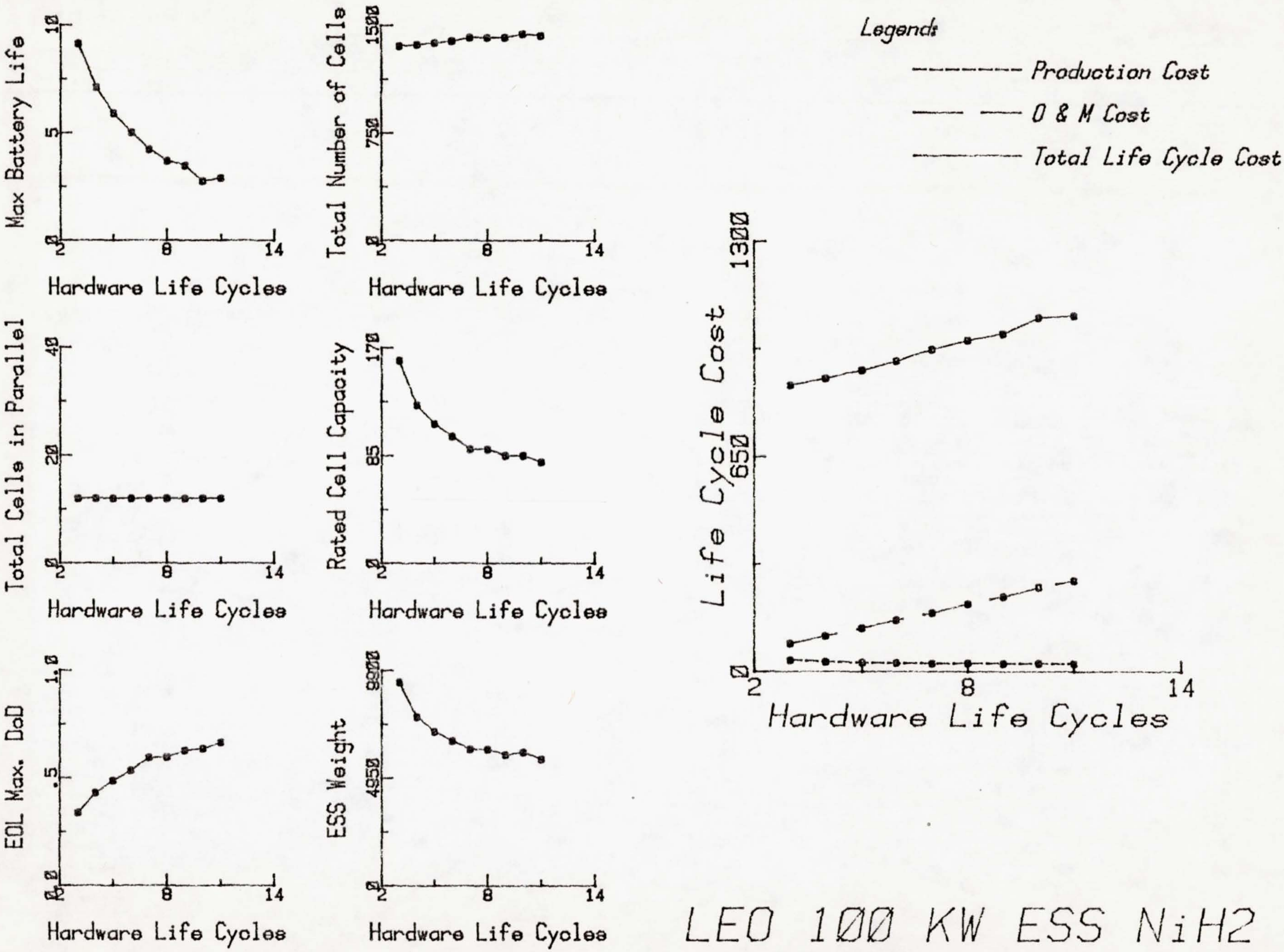

Exhibit 14c. Hardware Life Cycles (Capacity Variable) Continued

LEO 250KW ESS (NiH2)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	3	4	5	6	7	8	9	10	11
Maximum Battery Life (Yr)	9.148	7.028	5.687	4.760	4.173	3.772	3.304	3.061	2.889
Rated Cell Capacity (AH)	200	155	135	125	115	110	105	100	100
Maximum Depth of Discharge	.338	.434	.498	.538	.583	.607	.637	.667	.665
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	96.485	96.485	96.485	96.485	96.485	96.485	96.485	96.485	96.485
Minimum Voltage (V)	1.149	1.129	1.114	1.105	1.096	1.094	1.086	1.084	1.088
Recharge Fraction	1.071	1.071	1.071	1.071	1.074	1.076	1.078	1.081	1.081
Charge Current (A)	70.978	70.978	70.978	70.978	71.124	71.263	71.442	71.608	71.595
Charge Voltage (V)	1.702	1.704	1.706	1.708	1.707	1.703	1.709	1.706	1.699
Watt-Hour Efficiency	.630	.618	.610	.604	.598	.597	.589	.588	.593

PHYSICAL CHARACTERISTICS									
Total Number of Cells	2712	2760	2784	2808	2832	2832	2856	2856	2856
Number of Parallel Batteries	24	24	24	24	24	24	24	24	24
Number of Modules per Battery	5	5	5	5	5	5	5	5	5
Battery Cell Weight (Kg)	4.536	3.515	3.062	2.835	2.608	2.495	2.381	2.268	2.268
Battery Cell Volume (Cm^3)	5221	4675	4432	4310	4189	4128	4067	4007	4007
ESS Weight (Kg)	23204	19250	17461	16613	15744	15244	14873	14373	14350
ESS Volume (M^3)	85.319	89.383	89.383	89.383	89.383	89.383	89.383	89.383	89.383

LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	17.742	15.446	14.405	13.913	13.412	13.122	12.903	12.609	12.606
Production Cost	81.260	68.240	62.348	59.563	56.717	55.074	53.848	52.201	52.150
Operations & Maintenance Cost	186.139	232.556	281.201	332.698	379.938	429.368	478.402	523.318	577.747
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ESS LIFE CYCLE COST	285.141	316.242	357.954	406.174	450.067	497.564	545.153	588.128	642.503
Solar Array Cost	1490.221	1512.687	1524.857	1536.935	1549.430	1549.024	1566.456	1567.165	1562.339
Thermal Control Cost	26.975	27.294	27.520	27.779	27.958	27.739	28.455	28.329	27.809
Power Conditioning Cost	2.961	2.961	2.961	2.961	2.961	2.961	2.961	2.961	2.961
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TOTAL LIFE CYCLE COST	1805.298	1859.184	1913.292	1973.849	2030.416	2077.288	2143.025	2186.583	2235.612

Exhibit 14d. Hardware Life Cycles (Capacity Variable)

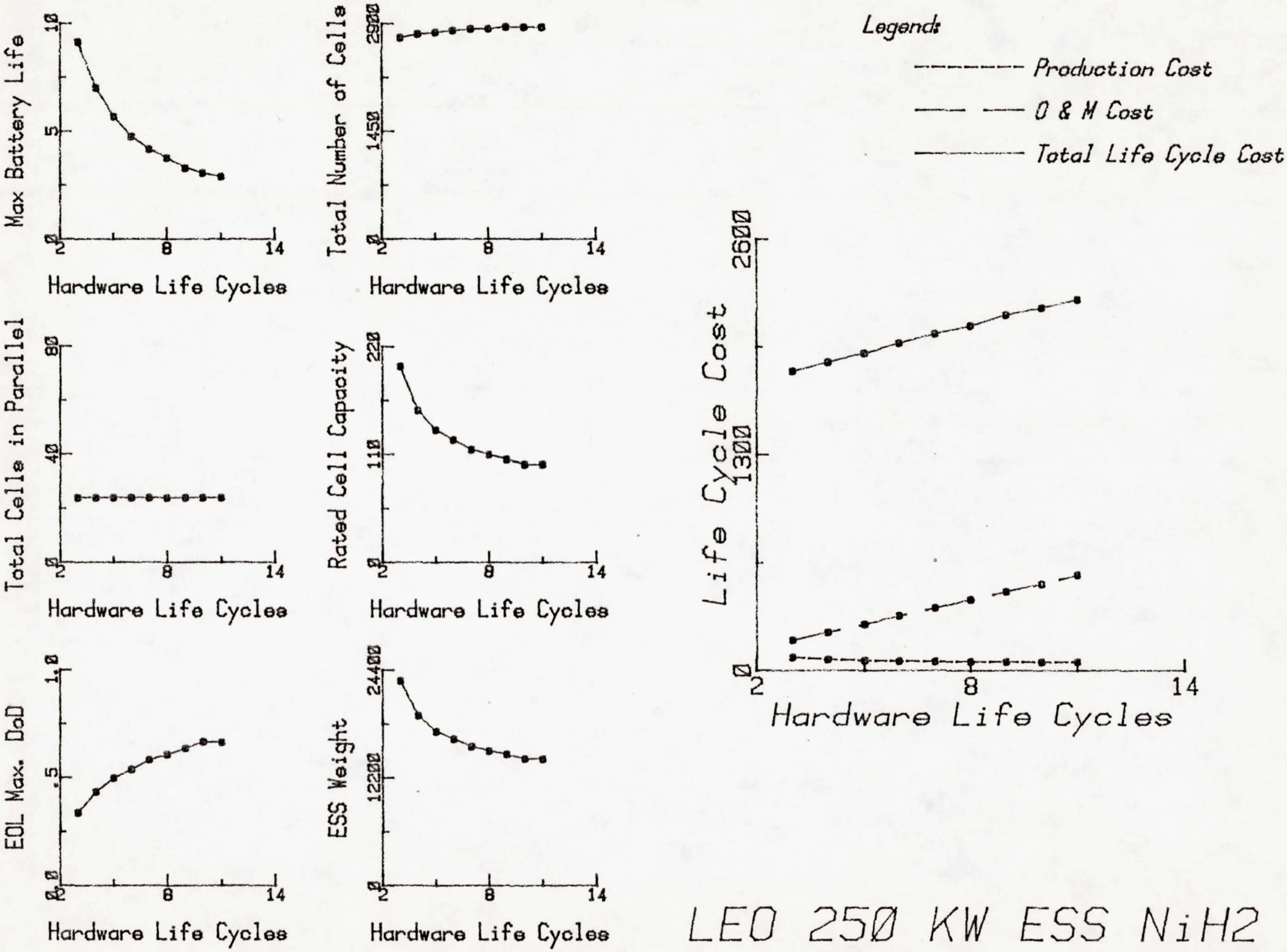

Exhibit 14d. Hardware Life Cycles (Capacity Variable) Continued

LEO 25KW ESS (NIH2)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	4	4	4	4	4	4	4	4	4
Maximum Battery Life (Yr)	9.092	7.912	7.424	7.154	6.983	7.111	7.272	7.154	7.060
Rated Cell Capacity (AH)	20	35	50	65	80	95	115	130	145
Maximum Depth of Discharge	.340	.394	.416	.429	.437	.440	.423	.429	.433
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	10.000	20.000	30.000	40.000	50.000	60.000	70.000	80.000	90.000
Minimum Voltage (V)	1.182	1.153	1.140	1.133	1.127	1.129	1.136	1.133	1.130
Recharge Fraction	1.071	1.072	1.071	1.072	1.071	1.071	1.072	1.072	1.072
Charge Current (A)	7.357	14.715	22.070	29.429	36.783	44.139	51.501	58.857	66.215
Charge Voltage (V)	1.655	1.680	1.692	1.700	1.705	1.702	1.697	1.700	1.703
Watt-Hour Efficiency	.667	.641	.629	.622	.617	.619	.625	.622	.619
PHYSICAL CHARACTERISTICS									
Total Number of Cells	2616	1344	904	684	575	460	456	456	460
Number of Parallel Batteries	24	12	8	6	5	4	4	4	4
Number of Modules per Battery	4	4	5	5	5	5	5	5	5
Battery Cell Weight (Kg)	.454	.794	1.134	1.474	1.814	2.155	2.608	2.948	3.289
Battery Cell Volume (Cm^3)	1547	1772	2020	3582	3764	3946	4189	4371	4553
ESS Weight (Kg)	2906	2357	2194	2109	2149	2021	2384	2685	3008
ESS Volume (M^3)	54.205	18.964	18.068	21.330	16.730	14.070	14.070	14.070	14.070
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	11.255	9.578	9.006	8.718	8.664	8.426	8.821	9.131	9.466
Production Cost	21.504	13.696	12.632	12.320	12.089	11.543	12.707	13.663	14.695
Operations & Maintenance Cost	119.971	64.703	55.845	46.936	42.479	36.980	39.365	41.260	43.326
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ESS LIFE CYCLE COST	152.730	87.977	77.483	67.974	63.232	56.949	60.893	64.054	67.487
Solar Array Cost	229.265	237.199	240.320	242.924	253.374	244.820	274.483	306.041	339.236
Thermal Control Cost	7.018	7.254	7.366	7.444	7.597	7.475	7.787	8.191	8.627
Power Conditioning Cost	2.961	1.645	1.166	.914	.783	.648	.648	.648	.648
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TOTAL LIFE CYCLE COST	391.974	334.075	326.335	319.256	324.986	309.892	343.811	378.934	415.998

Exhibit 15a. Discharge Current (Capacity Variable)

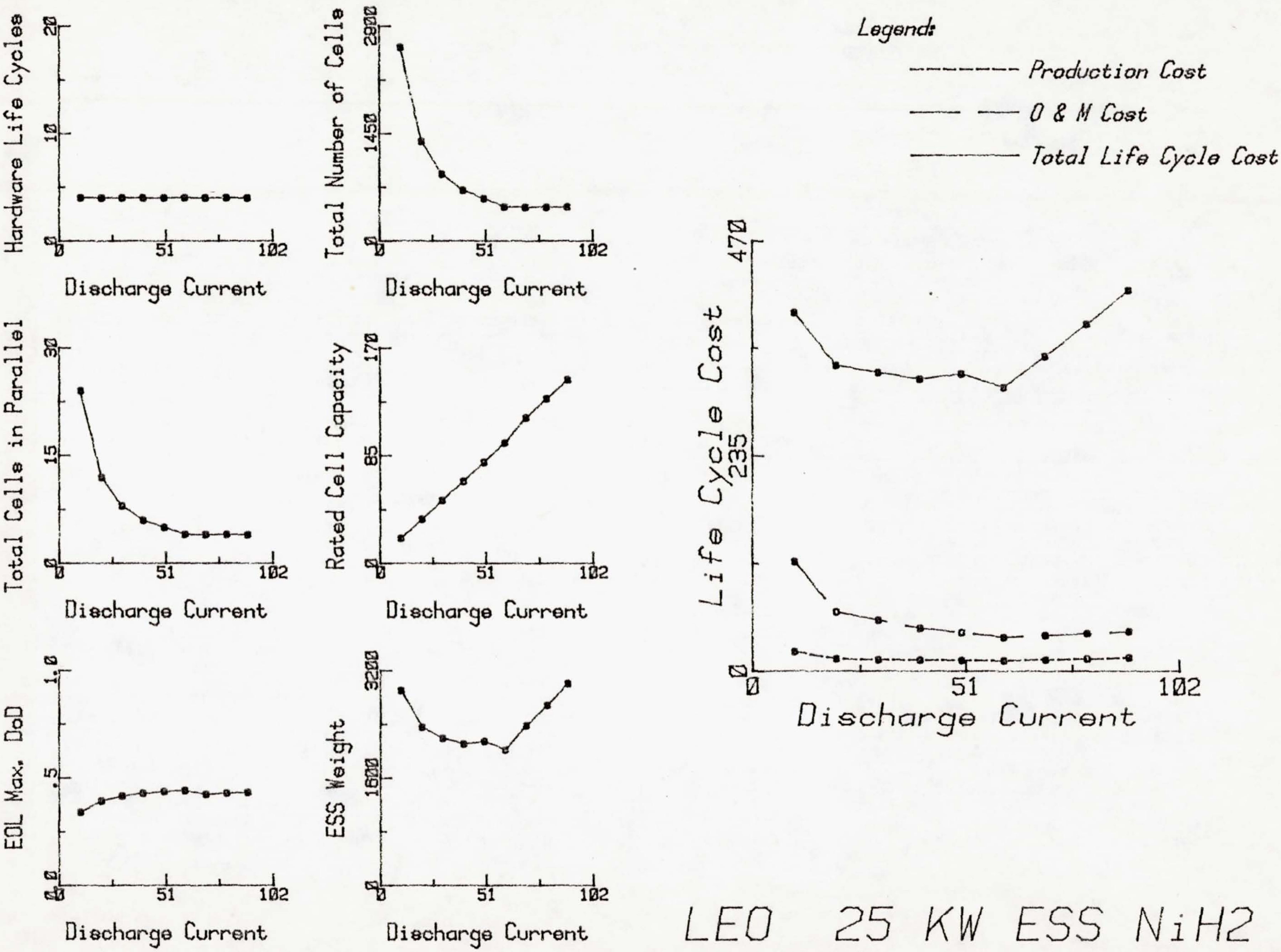

Exhibit 15a. Discharge Current (Capacity Variable) Continued

LEO 50KW ESS (NIH2)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	4	4	4	4	4	4	4	4	4
Maximum Battery Life (Yr)	9.092	7.912	7.424	7.154	6.983	7.111	7.272	7.154	7.060
Rated Cell Capacity (AH)	20	35	50	65	80	95	115	130	145
Maximum Depth of Discharge	.340	.394	.416	.429	.437	.440	.423	.429	.433
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	10.000	20.000	30.000	40.000	50.000	60.000	70.000	80.000	90.000
Minimum Voltage (V)	1.182	1.153	1.140	1.133	1.127	1.129	1.136	1.133	1.130
Recharge Fraction	1.071	1.072	1.071	1.072	1.071	1.071	1.072	1.072	1.072
Charge Current (A)	7.357	14.715	22.070	29.429	36.783	44.139	51.501	58.857	66.215
Charge Voltage (V)	1.655	1.680	1.692	1.700	1.705	1.702	1.697	1.700	1.703
Watt-Hour Efficiency	.667	.641	.629	.622	.617	.619	.625	.622	.619
PHYSICAL CHARACTERISTICS									
Total Number of Cells	5123	2688	1808	1368	1150	920	798	684	690
Number of Parallel Batteries	47	24	16	12	10	8	7	6	6
Number of Modules per Battery	4	4	5	5	5	5	5	5	5
Battery Cell Weight (Kg)	.454	.794	1.134	1.474	1.814	2.155	2.608	2.948	3.289
Battery Cell Volume (Cm^3)	1547	1772	2020	3582	3764	3946	4189	4371	4553
ESS Weight (Kg)	6010	4714	4387	4217	4297	4041	4171	4028	4512
ESS Volume (M^3)	108.410	61.946	36.137	42.660	33.459	29.859	28.888	21.330	22.346
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	14.962	12.065	11.028	10.509	10.398	9.980	10.013	9.790	10.232
Production Cost	37.992	25.133	20.622	20.019	19.557	18.481	18.773	18.186	19.727
Operations & Maintenance Cost	226.574	127.812	105.059	87.314	77.920	67.451	64.219	58.614	61.687
ESS LIFE CYCLE COST	279.528	165.010	136.709	117.842	107.875	95.912	93.005	86.590	91.646
Solar Array Cost	393.294	413.853	419.287	423.836	442.073	427.148	430.203	423.822	469.785
Thermal Control Cost	8.758	9.308	9.531	9.687	9.994	9.748	9.727	9.687	10.340
Power Conditioning Cost	5.236	2.961	2.100	1.645	1.409	1.166	1.042	.914	.914
TOTAL LIFE CYCLE COST	686.816	591.132	567.627	553.010	561.351	533.974	533.977	521.013	572.685

Exhibit 15b. Discharge Current (Capacity Variable)

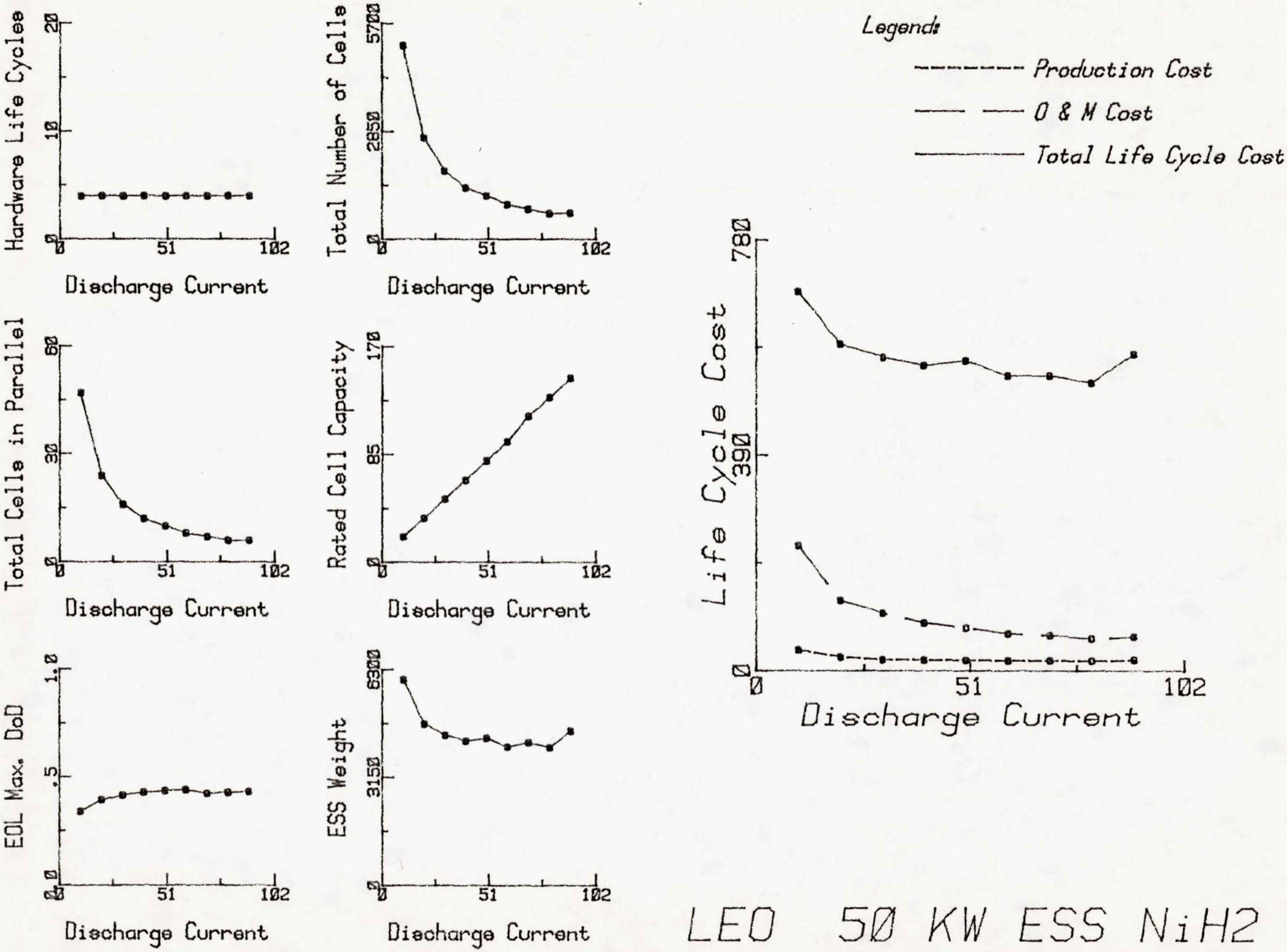

Exhibit 15b. Discharge Current (Capacity Variable) Continued

LEO 100KW ESS (NIH2)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	4	4	4	4	4	4	4	4	4
Maximum Battery Life (Yr)	9.092	7.912	7.424	7.154	6.983	7.111	7.272	7.154	7.060
Rated Cell Capacity (AH)	20	35	50	65	80	95	115	130	145
Maximum Depth of Discharge	.340	.394	.416	.429	.437	.440	.423	.429	.433
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	10.000	20.000	30.000	40.000	50.000	60.000	70.000	80.000	90.000
Minimum Voltage (V)	1.182	1.153	1.140	1.133	1.127	1.129	1.136	1.133	1.130
Recharge Fraction	1.071	1.072	1.071	1.072	1.071	1.071	1.072	1.072	1.072
Charge Current (A)	7.357	14.715	22.070	29.429	36.783	44.139	51.501	58.857	66.215
Charge Voltage (V)	1.655	1.680	1.692	1.700	1.705	1.702	1.697	1.700	1.703
Watt-Hour Efficiency	.667	.641	.629	.622	.617	.619	.625	.622	.619
PHYSICAL CHARACTERISTICS									
Total Number of Cells	10137	5264	3503	2736	2185	1840	1596	1368	1265
Number of Parallel Batteries	93	47	31	24	19	16	14	12	11
Number of Modules per Battery	4	4	5	5	5	5	5	5	5
Battery Cell Weight (Kg)	.454	.794	1.134	1.474	1.814	2.155	2.608	2.948	3.289
Battery Cell Volume (Cm^3)	1547	1772	2020	3582	3764	3946	4189	4371	4553
ESS Weight (Kg)	12220	9597	8819	8432	9367	8081	8342	8054	8836
ESS Volume (M^3)	216.830	123.890	72.273	89.578	86.664	59.719	57.776	42.660	44.692
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	22.218	16.770	14.780	14.092	13.543	13.116	13.168	12.756	12.900
Production Cost	70.722	45.090	36.136	34.646	35.398	32.237	32.828	31.656	33.405
Operations & Maintenance Cost	439.518	242.083	197.114	166.154	142.012	127.994	121.049	110.361	107.575
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ESS LIFE CYCLE COST	532.458	303.943	248.030	214.892	190.953	173.347	167.045	154.773	153.880
Solar Array Cost	680.342	709.950	713.144	739.461	740.150	745.255	750.594	739.461	764.344
Thermal Control Cost	12.242	13.243	13.591	14.172	14.308	14.296	14.253	14.172	14.623
Power Conditioning Cost	9.339	5.236	3.679	2.961	2.429	2.100	1.875	1.645	1.528
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TOTAL LIFE CYCLE COST	1234.381	1032.372	978.444	971.486	947.840	934.998	933.767	910.051	934.375

Exhibit 15c. Discharge Current (Capacity Variable)

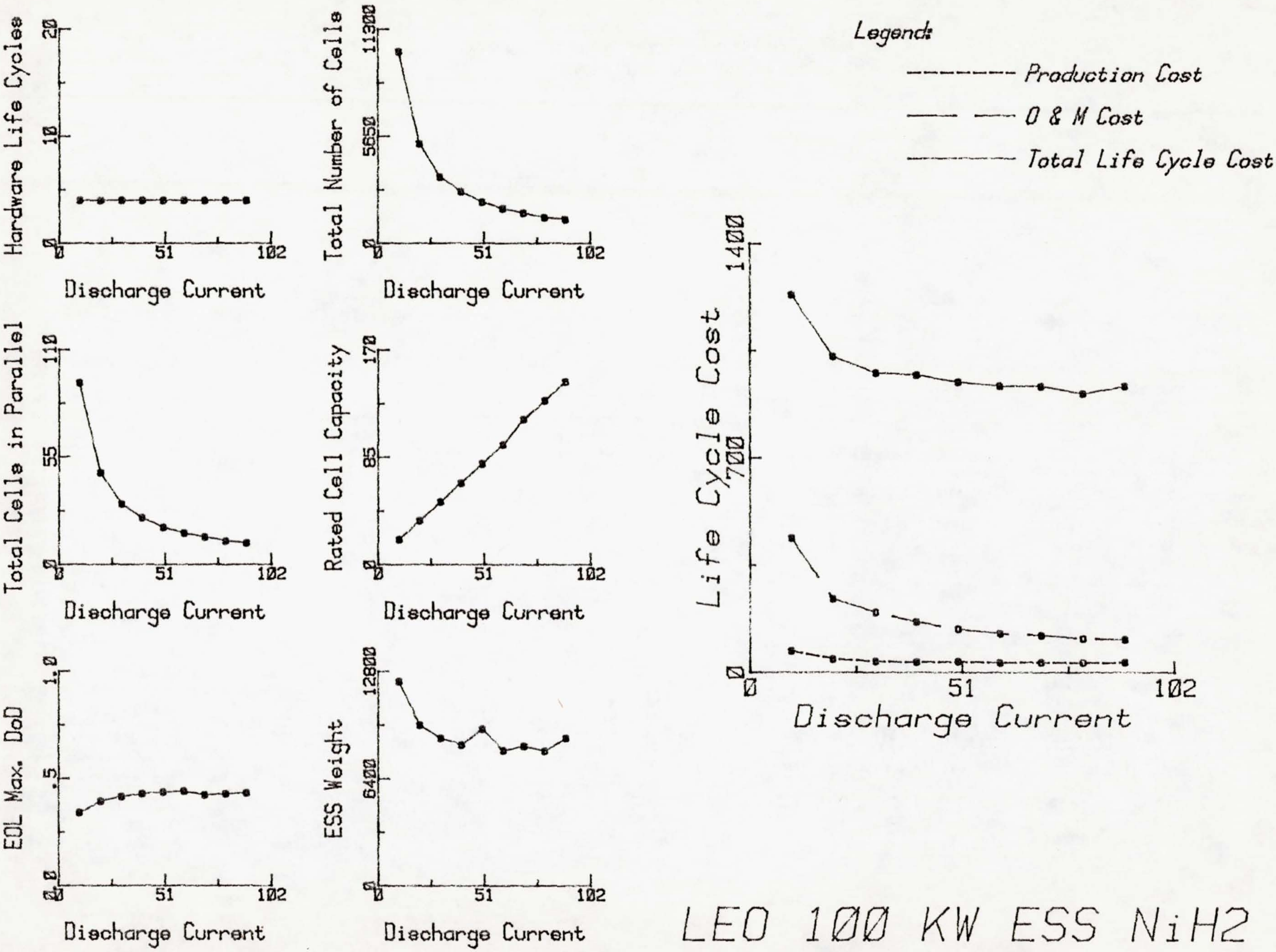

Exhibit 15c. Discharge Current (Capacity Variable) Continued

LEO 250KW ESS (NiH2)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	4	4	4	4	4	4	4	4	4
Maximum Battery Life (Yr)	9.092	7.912	7.424	7.154	6.983	7.111	7.272	7.154	7.060
Rated Cell Capacity (AH)	20	35	50	65	80	95	115	130	145
Maximum Depth of Discharge	.340	.394	.416	.429	.437	.440	.423	.429	.433
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	10.000	20.000	30.000	40.000	50.000	60.000	70.000	80.000	90.000
Minimum Voltage (V)	1.182	1.153	1.140	1.133	1.127	1.129	1.136	1.133	1.130
Recharge Fraction	1.071	1.072	1.071	1.072	1.071	1.071	1.072	1.072	1.072
Charge Current (A)	7.357	14.715	22.070	29.429	36.783	44.139	51.501	58.857	66.215
Charge Voltage (V)	1.655	1.680	1.692	1.700	1.705	1.702	1.697	1.700	1.703
Watt-Hour Efficiency	.667	.641	.629	.622	.617	.619	.625	.622	.619
PHYSICAL CHARACTERISTICS									
Total Number of Cells	25288	12992	8814	6612	5405	4485	3876	3306	2990
Number of Parallel Batteries	232	116	78	58	47	39	34	29	26
Number of Modules per Battery	4	4	5	5	5	5	5	5	5
Battery Cell Weight (Kg)	.454	.794	1.134	1.474	1.814	2.155	2.608	2.948	3.289
Battery Cell Volume (Cm^3)	1547	1772	2020	3582	3764	3946	4189	4371	4553
ESS Weight (Kg)	28081	24248	22023	23559	20725	20226	20858	21054	20751
ESS Volume (M^3)	523.990	309.730	180.680	238.880	179.160	149.300	144.440	119.440	115.550
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	31.058	22.368	19.505	17.996	17.195	16.491	16.525	15.879	15.757
Production Cost	164.565	104.407	82.840	82.538	75.089	72.519	73.853	72.802	71.923
Operations & Maintenance Cost	1090.030	583.566	482.930	388.653	339.334	301.030	282.841	256.049	243.199
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ESS LIFE CYCLE COST	1285.653	710.341	585.275	489.187	431.618	390.040	373.219	344.730	330.879
Solar Array Cost	1417.444	1466.541	1496.093	1501.925	1531.747	1524.110	1530.526	1501.891	1524.993
Thermal Control Cost	22.765	25.052	26.310	26.883	27.729	27.369	27.183	26.881	27.473
Power Conditioning Cost	20.275	11.264	8.045	6.258	5.236	4.469	3.979	3.477	3.169
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TOTAL LIFE CYCLE COST	2746.137	2213.198	2115.723	2024.253	1996.330	1945.988	1934.907	1876.979	1886.514

Exhibit 15d. Discharge Current (Capacity Variable)

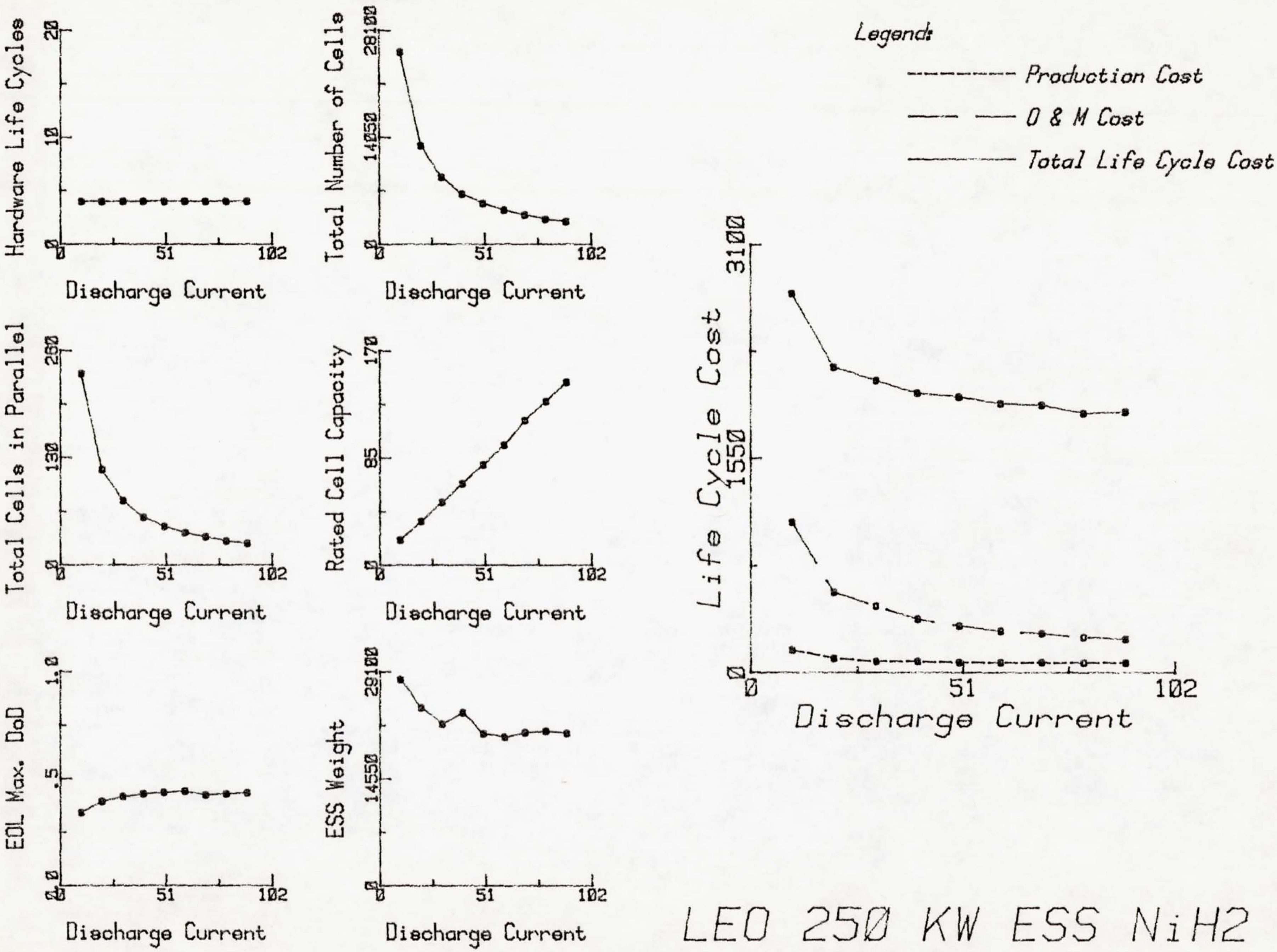

Exhibit 15d. Discharge Current (Capacity Variable) Continued

GEO 25KW ESS (NIH2)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	1	1	1	1	1	1	1	1	1
Maximum Battery Life (Yr)	1.238	1.238	1.238	1.238	.941	.745	.812	.860	.904
Rated Cell Capacity (AH)	15	30	45	60	75	85	100	115	130
Maximum Depth of Discharge	.793	.793	.793	.793	.795	.844	.836	.830	.826
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	10.000	20.000	30.000	40.000	50.000	60.000	70.000	80.000	90.000
Minimum Voltage (V)	1.211	1.211	1.211	1.211	1.208	1.192	1.196	1.199	1.201
Recharge Fraction	1.412	1.412	1.412	1.412	1.422	1.581	1.586	1.590	1.593
Charge Current (A)	.734	1.468	2.202	2.936	3.696	6.239	6.780	7.334	7.892
Charge Voltage (V)	1.490	1.490	1.490	1.490	1.494	1.506	1.502	1.500	1.498
Watt-Hour Efficiency	.575	.575	.576	.576	.569	.396	.427	.453	.475
PHYSICAL CHARACTERISTICS									
Total Number of Cells	2568	1284	856	642	535	436	432	432	432
Number of Parallel Batteries	24	12	8	6	5	4	4	4	4
Number of Modules per Battery	4	4	4	4	4	4	4	4	4
Battery Cell Weight (Kg)	.340	.680	1.021	1.361	1.701	1.928	2.268	2.608	2.948
Battery Cell Volume (Cm^3)	1479	1695	1936	3521	3703	3825	4007	4189	4371
ESS Weight (Kg)	2376	2000	1875	1812	1848	1701	1961	2234	2506
ESS Volume (M^3)	49.043	15.803	16.348	19.298	17.658	6.253	9.380	9.380	9.380
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	9.966	8.587	8.119	7.884	7.839	7.600	7.868	8.148	8.421
Production Cost	60.796	34.986	32.671	33.126	33.228	29.652	33.405	37.353	41.288
Operations & Maintenance Cost	.500	.500	.500	.500	.500	.500	.500	.500	.500
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ESS LIFE CYCLE COST	71.262	44.073	41.290	41.510	41.567	37.752	41.773	46.001	50.209
Solar Array Cost	14.767	14.766	14.763	14.764	15.371	19.988	21.169	22.520	23.864
Thermal Control Cost	5.870	5.870	5.870	5.870	5.898	5.921	6.022	6.133	6.244
Power Conditioning Cost	2.961	1.645	1.166	.914	.783	.648	.648	.648	.648
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TOTAL LIFE CYCLE COST	94.860	66.354	63.089	63.058	63.619	64.309	69.612	75.302	80.965

Exhibit 15e. Discharge Current (Capacity Variable)

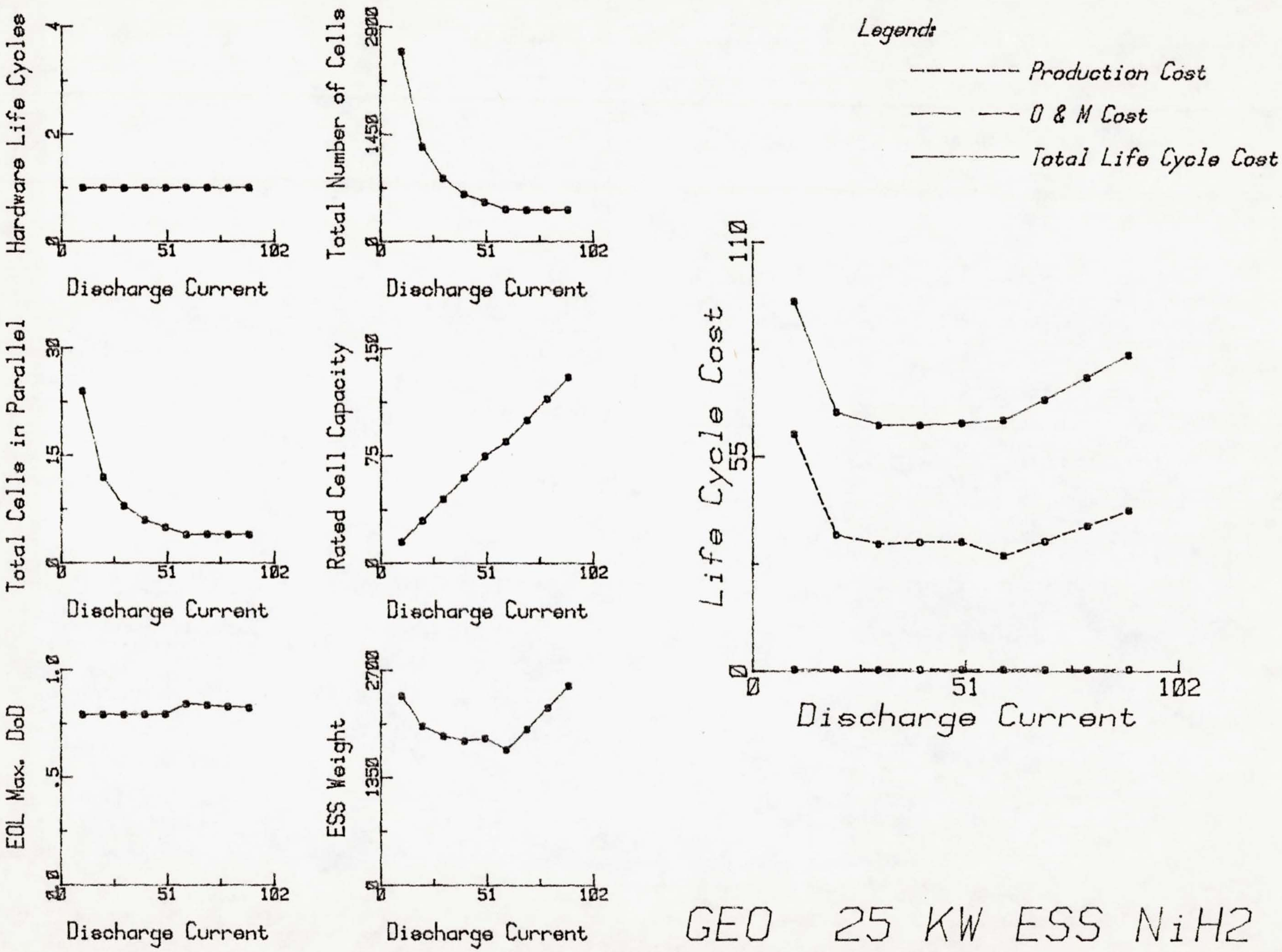

Exhibit 15e. Discharge Current (Capacity Variable) Continued

LEO 25KW ESS (NiH2)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	3	4	5	6	7	8	9	10	11
Maximum Battery Life (Yr)	9.476	7.785	6.601	5.020	5.194	4.212	3.184	3.342	3.455
Rated Cell Capacity (AH)	50	50	50	50	50	50	50	50	50
Maximum Depth of Discharge	.323	.400	.454	.535	.525	.529	.645	.635	.628
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	23.157	28.946	33.080	38.594	38.594	38.594	46.313	46.313	46.313
Minimum Voltage (V)	1.158	1.150	1.143	1.112	1.135	1.126	1.080	1.099	1.113
Recharge Fraction	1.072	1.072	1.071	1.071	1.071	1.072	1.079	1.078	1.078
Charge Current (A)	17.038	21.296	24.335	28.391	28.391	28.394	34.314	34.286	34.267
Charge Voltage (V)	1.694	1.683	1.677	1.698	1.667	1.679	1.716	1.688	1.668
Watt-Hour Efficiency	.638	.638	.636	.611	.635	.626	.583	.604	.619
PHYSICAL CHARACTERISTICS									
Total Number of Cells	1120	904	791	696	684	690	600	590	580
Number of Parallel Batteries	10	8	7	6	6	6	5	5	5
Number of Modules per Battery	4	5	5	5	5	5	5	5	5
Battery Cell Weight (Kg)	1.134	1.134	1.134	1.134	1.134	1.134	1.134	1.134	1.134
Battery Cell Volume (Cm^3)	2020	2020	2020	2020	2020	2020	2020	2020	2020
ESS Weight (Kg)	2598	2178	1948	1761	1728	1743	1575	1545	1519
ESS Volume (M^3)	17.353	18.068	14.983	14.223	14.223	14.223	7.953	7.953	7.953
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	9.673	8.998	8.629	8.316	8.271	8.291	7.994	7.954	7.917
Production Cost	14.249	12.593	11.696	10.955	10.840	10.893	10.208	10.107	10.015
Operations & Maintenance Cost	43.209	55.824	63.423	67.738	79.244	91.308	90.673	100.631	110.500
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ESS LIFE CYCLE COST	67.131	77.415	83.748	87.009	98.355	110.492	108.875	118.692	128.432
Solar Array Cost	232.055	232.476	231.797	239.101	232.336	235.305	249.183	242.503	236.846
Thermal Control Cost	7.304	7.223	7.165	7.362	7.090	7.197	7.607	7.345	7.151
Power Conditioning Cost	1.409	1.166	1.042	.914	.914	.914	.783	.783	.783
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TOTAL LIFE CYCLE COST	307.899	318.280	323.752	334.386	338.695	353.908	366.448	369.323	373.212

Exhibit 16a. Hardware Life Cycles (Capacity Fixed)

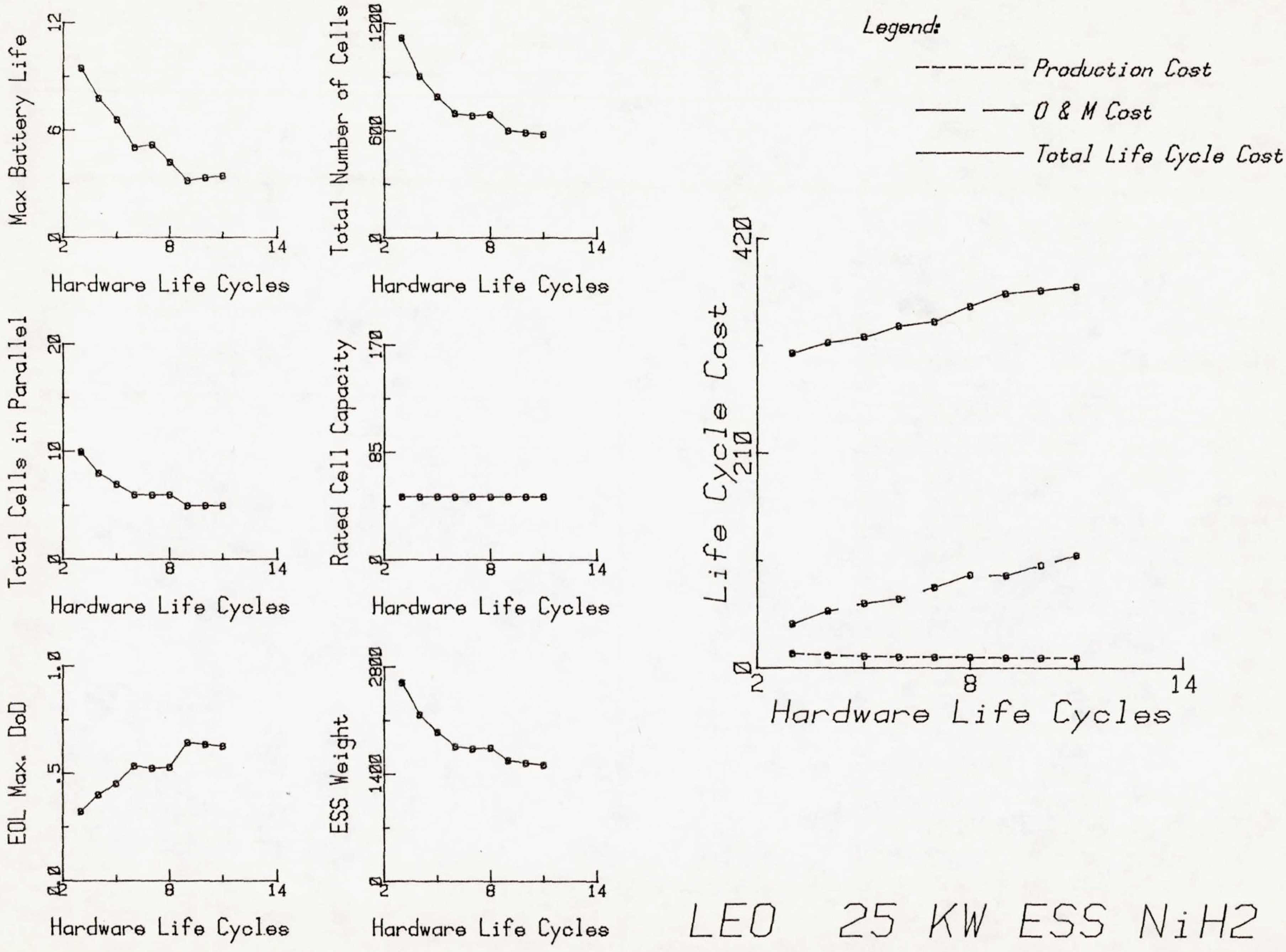

Exhibit 16a. Hardware Life Cycles (Capacity Fixed) Continued

LEO 50KW ESS (NiH2)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	3	4	5	6	7	8	9	10	11
Maximum Battery Life (Yr)	9.476	7.117	5.725	5.020	4.125	4.295	3.184	3.342	3.455
Rated Cell Capacity (AH)	50	50	50	50	50	50	50	50	50
Maximum Depth of Discharge	.323	.430	.496	.535	.586	.576	.645	.635	.628
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	23.157	30.875	35.626	38.594	42.103	42.103	46.313	46.313	46.313
Minimum Voltage (V)	1.158	1.131	1.116	1.112	1.094	1.116	1.080	1.099	1.113
Recharge Fraction	1.072	1.072	1.071	1.071	1.074	1.073	1.079	1.078	1.078
Charge Current (A)	17.038	22.715	26.209	28.391	31.042	31.016	34.314	34.286	34.267
Charge Voltage (V)	1.694	1.701	1.705	1.698	1.710	1.679	1.716	1.688	1.668
Watt-Hour Efficiency	.638	.621	.611	.611	.596	.620	.583	.604	.619
PHYSICAL CHARACTERISTICS									
Total Number of Cells	2240	1710	1508	1392	1298	1276	1200	1180	1160
Number of Parallel Batteries	20	15	13	12	11	11	10	10	10
Number of Modules per Battery	4	5	5	5	5	5	5	5	5
Battery Cell Weight (Kg)	1.134	1.134	1.134	1.134	1.134	1.134	1.134	1.134	1.134
Battery Cell Volume (Cm^3)	2020	2020	2020	2020	2020	2020	2020	2020	2020
ESS Weight (Kg)	5611	4488	4071	3521	3698	3635	3148	3090	3038
ESS Volume (M^3)	59.931	36.137	29.965	28.446	28.446	28.446	15.907	15.907	15.907
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	12.250	10.788	10.215	9.832	9.621	9.553	9.281	9.217	9.154
Production Cost	25.319	20.471	18.872	17.301	17.331	17.117	15.829	15.632	15.446
Operations & Maintenance Cost	82.755	99.444	111.075	124.747	136.688	156.136	163.378	181.126	198.637
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ESS LIFE CYCLE COST	120.324	130.703	140.162	151.880	163.640	182.806	188.488	205.975	223.237
Solar Array Cost	404.868	412.037	418.532	417.170	426.020	413.946	434.760	423.101	413.235
Thermal Control Cost	9.407	9.545	9.645	9.524	9.790	9.233	10.013	9.489	9.102
Power Conditioning Cost	2.537	1.988	1.761	1.645	1.528	1.528	1.409	1.409	1.409
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TOTAL LIFE CYCLE COST	537.136	554.273	570.100	580.219	600.978	607.513	634.670	639.974	646.983

Exhibit 16b. Hardware Life Cycles (Capacity Fixed)

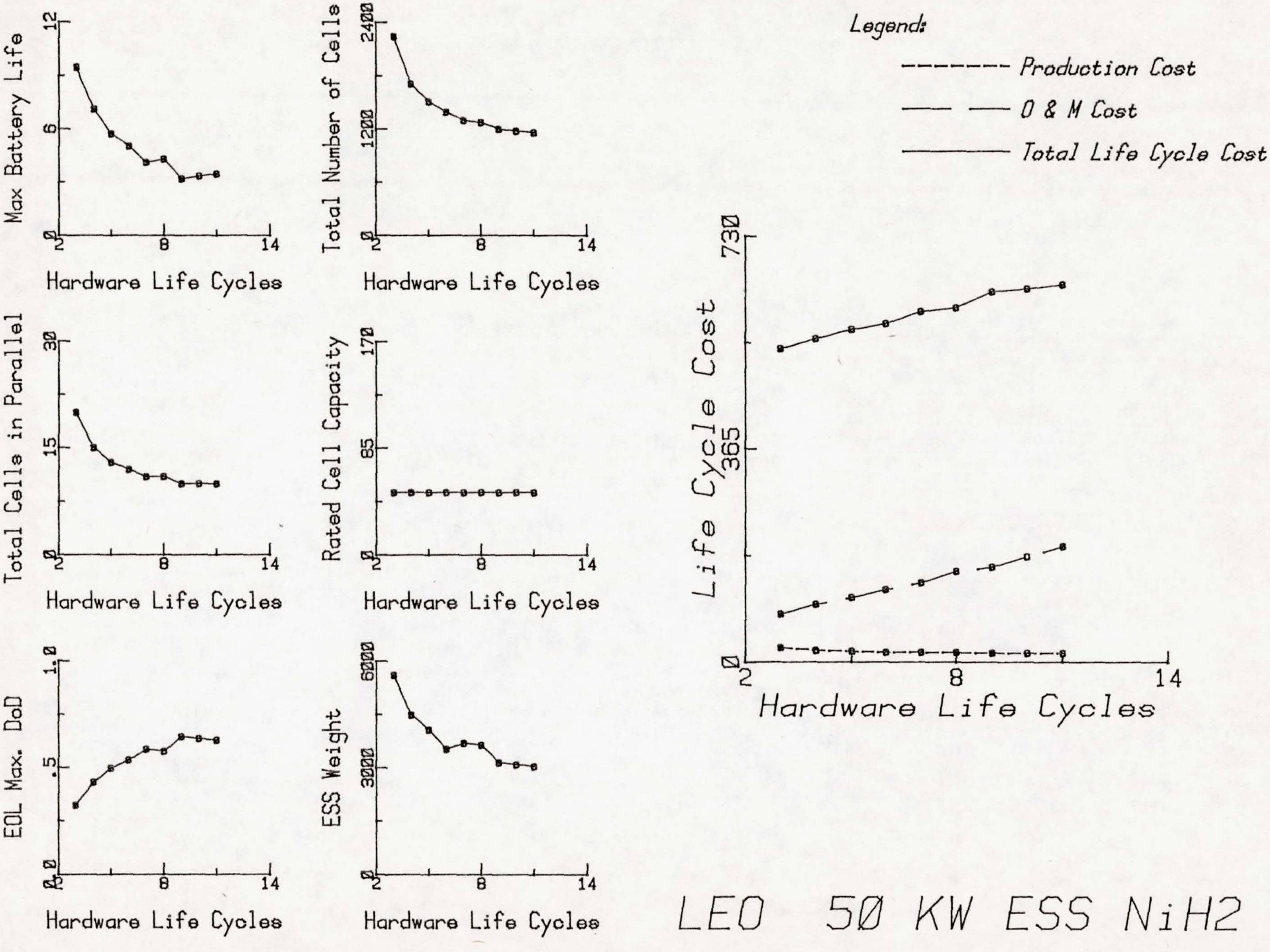

Exhibit 16b. Hardware Life Cycles (Capacity Fixed) Continued

LEO 100KW ESS (NIH2)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	3	4	5	6	7	8	9	10	11
Maximum Battery Life (Yr)	9.275	7.117	5.725	4.748	4.125	3.697	3.184	2.963	2.733
Rated Cell Capacity (AH)	50	50	50	50	50	50	50	50	50
Maximum Depth of Discharge	.332	.430	.496	.538	.586	.612	.645	.643	.676
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	23.750	30.875	35.626	38.594	42.103	44.108	46.313	46.313	48.750
Minimum Voltage (V)	1.153	1.131	1.116	1.105	1.094	1.091	1.080	1.085	1.080
Recharge Fraction	1.071	1.072	1.071	1.071	1.074	1.076	1.079	1.079	1.082
Charge Current (A)	17.472	22.715	26.209	28.391	31.042	32.594	34.314	34.308	36.204
Charge Voltage (V)	1.699	1.701	1.705	1.709	1.710	1.707	1.716	1.710	1.710
Watt-Hour Efficiency	.633	.621	.611	.603	.596	.593	.583	.588	.584
PHYSICAL CHARACTERISTICS									
Total Number of Cells	4368	3420	3016	2808	2596	2499	2400	2380	2280
Number of Parallel Batteries	39	30	26	24	22	21	20	20	19
Number of Modules per Battery	4	5	5	5	5	5	5	5	5
Battery Cell Weight (Kg)	1.134	1.134	1.134	1.134	1.134	1.134	1.134	1.134	1.134
Battery Cell Volume (Cm^3)	2020	2020	2020	2020	2020	2020	2020	2020	2020
ESS Weight (Kg)	10536	8974	8141	7101	7350	6480	6607	6559	6673
ESS Volume (M^3)	103.240	72.273	59.931	56.784	56.784	44.948	44.948	44.948	44.948
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	16.939	14.591	13.553	12.964	12.473	12.162	11.935	11.881	11.650
Production Cost	42.695	36.164	32.999	30.094	29.860	27.700	27.615	27.440	27.321
Operations & Maintenance Cost	155.059	191.317	212.301	238.779	259.018	286.012	308.955	343.236	362.684
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ESS LIFE CYCLE COST	214.693	242.072	258.853	281.837	301.351	325.874	348.505	382.557	401.655
Solar Array Cost	707.901	718.908	730.240	736.580	743.271	748.937	758.545	751.200	757.819
Thermal Control Cost	13.744	13.887	14.090	14.249	14.379	14.430	14.825	14.543	14.670
Power Conditioning Cost	4.469	3.578	3.169	2.961	2.750	2.644	2.537	2.537	2.429
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TOTAL LIFE CYCLE COST	940.807	978.445	1006.352	1035.627	1061.751	1091.885	1124.412	1150.837	1176.573

Exhibit 16c. Hardware Life Cycles (Capacity Fixed)

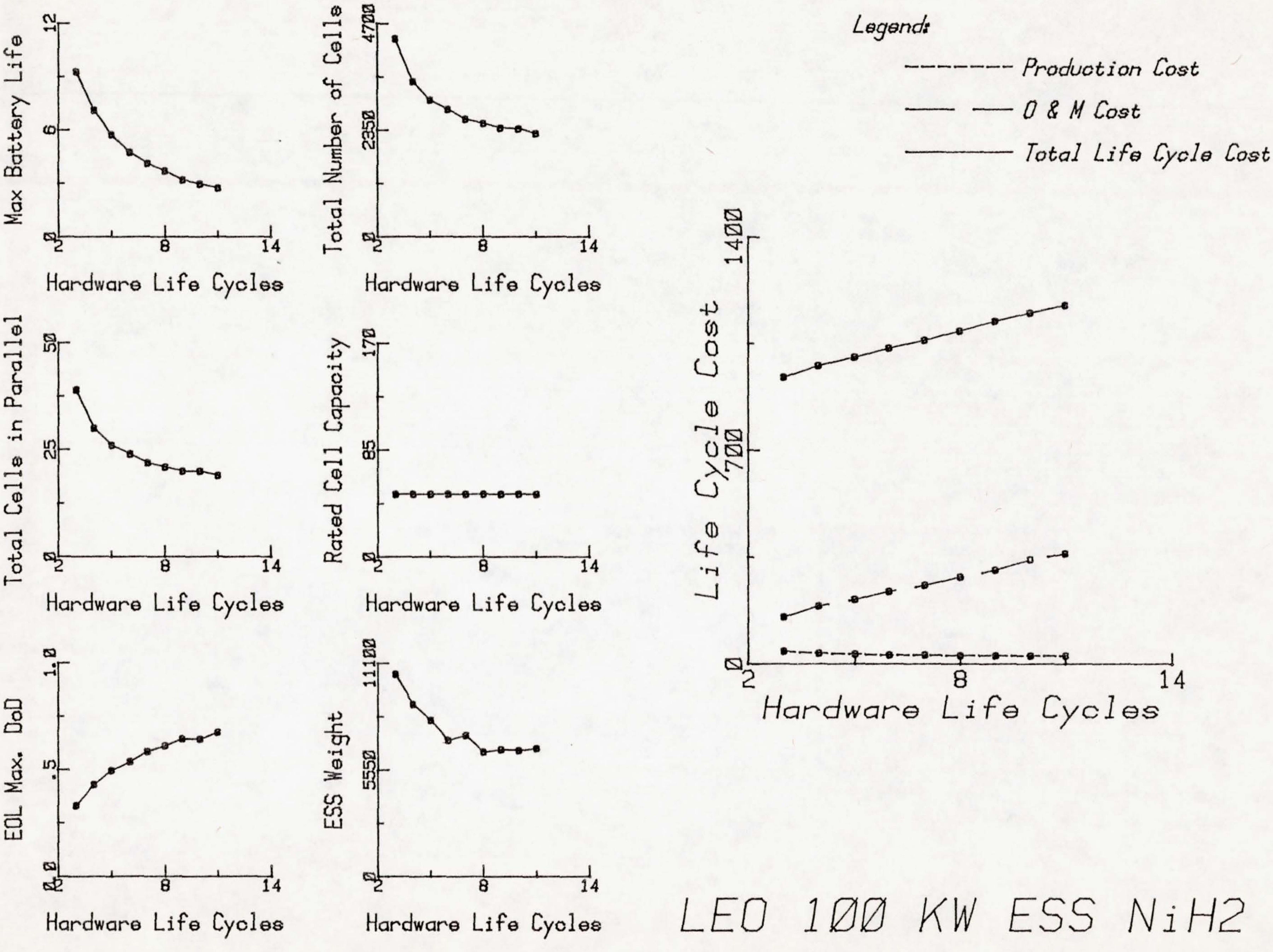

Exhibit 16c. Hardware Life Cycles (Capacity Fixed) Continued

LEO 250KW ESS (NIH2)

EOL PERFORMANCE PARAMETERS									
Hardware Life Cycles	3	4	5	6	7	8	9	10	11
Maximum Battery Life (Yr)	9.148	6.968	5.544	4.584	3.999	3.568	3.184	2.872	2.570
Rated Cell Capacity (AH)	50	50	50	50	50	50	50	50	50
Maximum Depth of Discharge	.338	.437	.506	.559	.588	.621	.645	.672	.687
Operating Temperature (deg-K)	283	283	283	283	283	283	283	283	283
Max. Discharge Current (A)	24.122	31.292	36.182	39.925	42.103	44.531	46.313	48.242	49.268
Minimum Voltage (V)	1.149	1.127	1.109	1.095	1.090	1.084	1.080	1.076	1.071
Recharge Fraction	1.071	1.072	1.071	1.072	1.074	1.077	1.079	1.081	1.083
Charge Current (A)	17.745	23.022	26.617	29.373	31.048	32.930	34.314	35.814	36.646
Charge Voltage (V)	1.702	1.706	1.712	1.717	1.716	1.715	1.716	1.718	1.722
Watt-Hour Efficiency	.630	.617	.605	.595	.592	.587	.583	.579	.574
PHYSICAL CHARACTERISTICS									
Total Number of Cells	10848	8510	7488	6844	6545	6188	6000	5760	5687
Number of Parallel Batteries	96	74	64	58	55	52	50	48	47
Number of Modules per Battery	5	5	5	5	5	5	5	5	5
Battery Cell Weight (Kg)	1.134	1.134	1.134	1.134	1.134	1.134	1.134	1.134	1.134
Battery Cell Volume (Cm^3)	2020	2020	2020	2020	2020	2020	2020	2020	2020
ESS Weight (Kg)	25472	22771	18702	19437	17154	17452	17754	15268	15477
ESS Volume (M^3)	216.830	189.280	151.420	151.420	132.500	132.500	132.500	113.570	113.570
LIFE CYCLE COSTS (1980M$)									
DDT&E Cost	22.750	19.059	17.326	16.362	15.804	15.267	14.987	14.507	14.405
Production Cost	96.968	83.337	71.349	70.659	64.867	64.257	64.232	58.222	58.408
Operations & Maintenance Cost	436.475	461.213	508.756	560.695	626.958	681.302	742.616	795.684	862.771
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ESS LIFE CYCLE COST	556.193	563.609	597.431	647.716	707.629	760.826	821.835	868.413	935.584
Solar Array Cost	1490.221	1514.082	1539.443	1554.029	1566.524	1569.290	1583.135	1587.272	1603.494
Thermal Control Cost	26.973	27.435	28.122	28.623	28.831	28.879	29.266	29.511	30.169
Power Conditioning Cost	9.594	7.694	6.803	6.258	5.982	5.704	5.518	5.330	5.236
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TOTAL LIFE CYCLE COST	2082.981	2112.820	2171.799	2236.626	2308.966	2364.699	2439.754	2490.526	2574.483

Exhibit 16d. Hardware Life Cycles (Capacity Fixed)

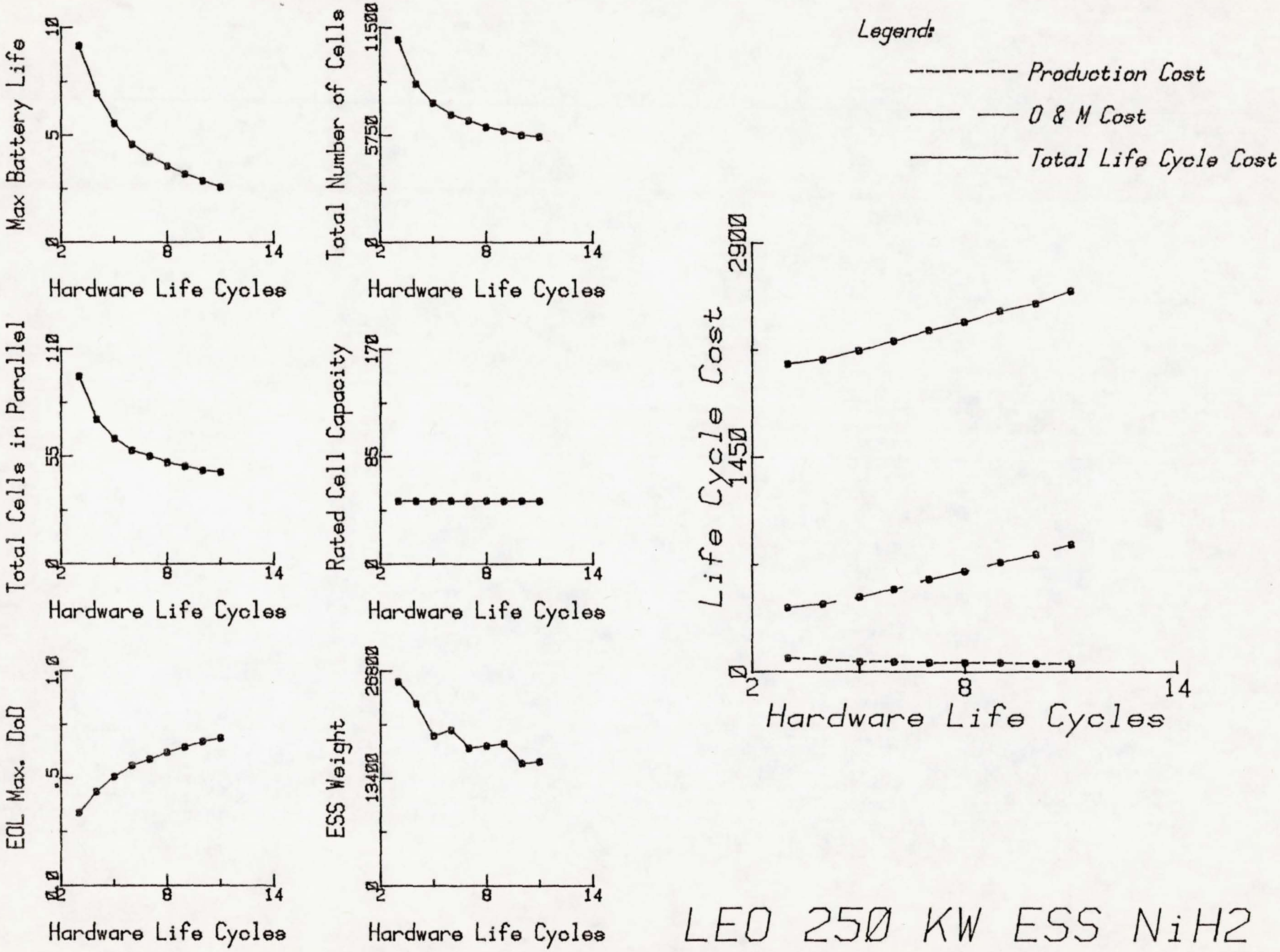

Exhibit 16d. Hardware Life Cycles (Capacity Fixed) Continued

LEO 25KW ESS (H202)

EOL FCU PERFORMANCE									
Hardware Life Cycles	3	5	6	7	8	9	10	12	14
Maximum FCU Life (Hr)	22537	15506	12177	10125	8742	7530	6451	5455	4551
Dark Period Power (W)	32.31	48.74	64.97	81.26	97.55	113.80	130.04	146.30	162.52
Dark Period Voltage (V)	1.391	1.399	1.399	1.400	1.400	1.400	1.400	1.400	1.400
Active Cell Area (cm2)	232.26	232.26	232.26	232.26	232.26	232.26	232.26	232.26	232.26
Current Density (Ma/cm2)	100.00	150.00	200.00	250.00	300.00	350.00	400.00	450.00	500.00
Operating Pressure (Kg/cm2)	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125
Operating Temperature (Deg-K)	355	355	355	355	355	355	355	355	355
EOL ECU PERFORMANCE									
Light Period Power (W)	34.44	33.79	34.26	34.34	34.56	34.06	34.41	34.09	34.41
Light Period Voltage (V)	3.458	3.448	3.478	3.488	3.499	3.445	3.455	3.466	3.476
EOL SUBSYSTEM PERFORMANCE									
Hardware Life Cycles	4	4	4	4	4	4	4	4	4
Maximum Pump Life (Hr)	62393	62393	62393	62393	62393	62393	62393	62393	62393
H2 Storage Weight (Kg)	1.443	1.361	1.547	1.605	1.521	1.343	1.533	1.723	1.912
DoD Factor	.800	.800	.800	.800	.800	.800	.800	.800	.800
Watt-Hour Efficiency	.404	.412	.411	.411	.411	.418	.418	.417	.416
PHYSICAL CHARACTERISTICS									
Total Number of FCU	1023	651	558	465	368	279	279	279	279
Total Number of ECU	1632	1564	1768	1836	1734	1530	1734	1972	2176
ESS Weight (Kg)	2386	2068	2246	2281	2118	1840	2079	2340	2581
ESS Volume (M^3)	15.051	15.051	15.051	15.051	15.051	15.051	15.051	15.051	15.051
LIFE CYCLE COSTS (1980$M)									
DDT&E Cost	17.907	16.274	16.905	16.920	16.102	14.807	15.778	16.838	17.777
Production Cost	23.647	20.968	22.091	22.168	20.815	18.657	20.322	22.151	23.791
Operations & Maintenance Cost	44.444	48.187	53.329	55.250	53.245	48.762	54.415	62.961	70.951
ESS LIFE CYCLE COST	85.998	85.429	92.325	94.338	90.162	82.226	90.515	101.950	112.519
Solar Array Cost	361.853	344.397	384.247	396.855	380.938	340.473	379.592	417.767	455.533
Thermal Control Cost	6.048	6.032	6.260	6.412	6.437	6.372	6.615	6.880	7.155
Power Conditioning Cost	1.528	1.042	.914	.783	.648	.508	.508	.508	.508
TOTAL LIFE CYCLE COST	455.427	436.900	483.746	498.388	478.185	429.579	477.230	527.105	575.715

Exhibit 17a. FCU Current Density

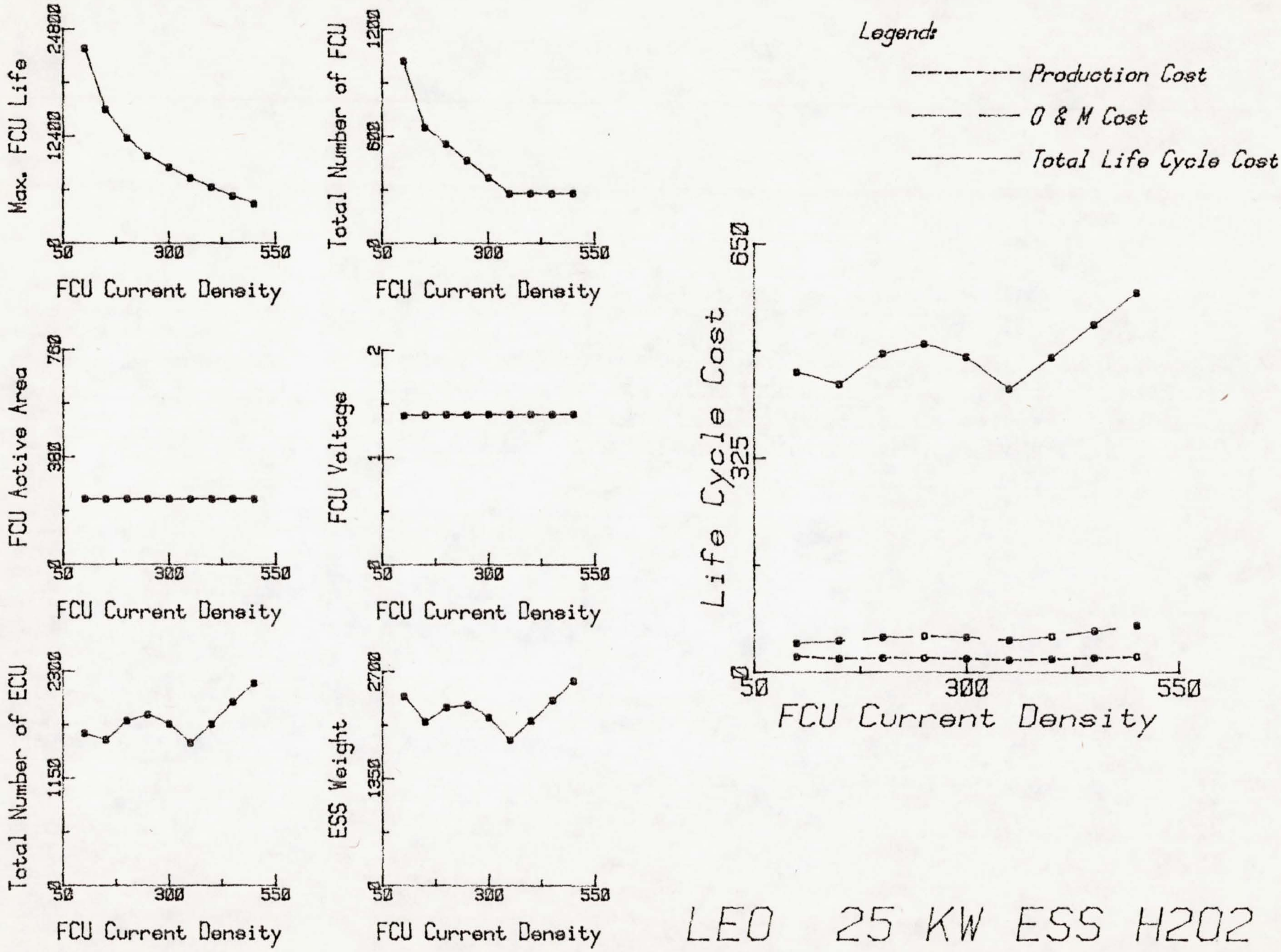

Exhibit 17a. FCU Current Density (Continued)

LEO 50KW ESS (H202)

EOL FCU PERFORMANCE									
Hardware Life Cycles	3	5	6	7	8	9	10	12	14
Maximum FCU Life (Hr)	22537	15506	12177	10125	8742	7530	6451	5455	4551
Dark Period Power (W)	32.31	48.74	64.97	81.26	97.55	113.80	130.04	146.30	162.52
Dark Period Voltage (V)	1.391	1.399	1.399	1.400	1.400	1.400	1.400	1.400	1.400
Active Cell Area (cm2)	232.26	232.26	232.26	232.26	232.26	232.26	232.26	232.26	232.26
Current Density (Ma/cm2)	100.00	150.00	200.00	250.00	300.00	350.00	400.00	450.00	500.00
Operating Pressure (Kg/cm2)	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125
Operating Temperature (Deg-K)	355	355	355	355	355	355	355	355	355
EOL ECU PERFORMANCE									
Light Period Power (W)	34.30	34.18	34.39	34.79	34.66	34.06	34.41	34.34	34.64
Light Period Voltage (V)	3.458	3.448	3.478	3.488	3.499	3.445	3.455	3.466	3.476
EOL SUBSYSTEM PERFORMANCE									
Hardware Life Cycles	4	4	4	4	4	4	4	4	4
Maximum Pump Life (Hr)	62393	62393	62393	62393	62393	62393	62393	62393	62393
H2 Storage Weight (Kg)	2.755	2.723	2.835	2.889	2.661	2.686	3.065	2.871	3.187
DoD Factor	.800	.800	.800	.800	.800	.800	.800	.800	.800
Watt-Hour Efficiency	.404	.412	.411	.411	.411	.418	.417	.417	.416
PHYSICAL CHARACTERISTICS									
Total Number of FCU	1953	1302	1023	837	644	558	558	465	465
Total Number of ECU	3128	3094	3230	3264	3026	3060	3468	3264	3604
ESS Weight (Kg)	4564	4109	4092	4054	3689	3675	4150	3872	4265
ESS Volume (M^3)	26.003	26.003	26.003	26.003	20.800	20.800	26.003	26.003	26.003
LIFE CYCLE COSTS (1980$M)									
DDT&E Cost	26.122	23.913	23.567	23.171	21.551	21.371	23.098	21.914	23.320
Production Cost	39.890	36.125	35.633	35.039	32.216	31.949	35.116	33.033	35.620
Operations & Maintenance Cost	77.203	85.601	88.240	89.281	83.921	85.088	95.167	94.390	106.387
	--------	--------	--------	--------	--------	--------	--------	--------	--------
ESS LIFE CYCLE COST	143.215	145.639	147.440	147.491	137.688	138.408	153.381	149.337	165.327
Solar Array Cost	608.102	601.083	625.239	636.507	597.129	593.989	662.338	629.765	686.685
Thermal Control Cost	6.819	6.864	7.141	7.381	7.364	7.543	8.028	7.997	8.458
Power Conditioning Cost	2.644	1.875	1.528	1.289	1.042	.914	.914	.783	.783
	--------	--------	--------	--------	--------	--------	--------	--------	--------
TOTAL LIFE CYCLE COST	760.780	755.461	781.348	792.668	743.223	740.854	824.661	787.882	861.253

Exhibit 17b. FCU Current Density

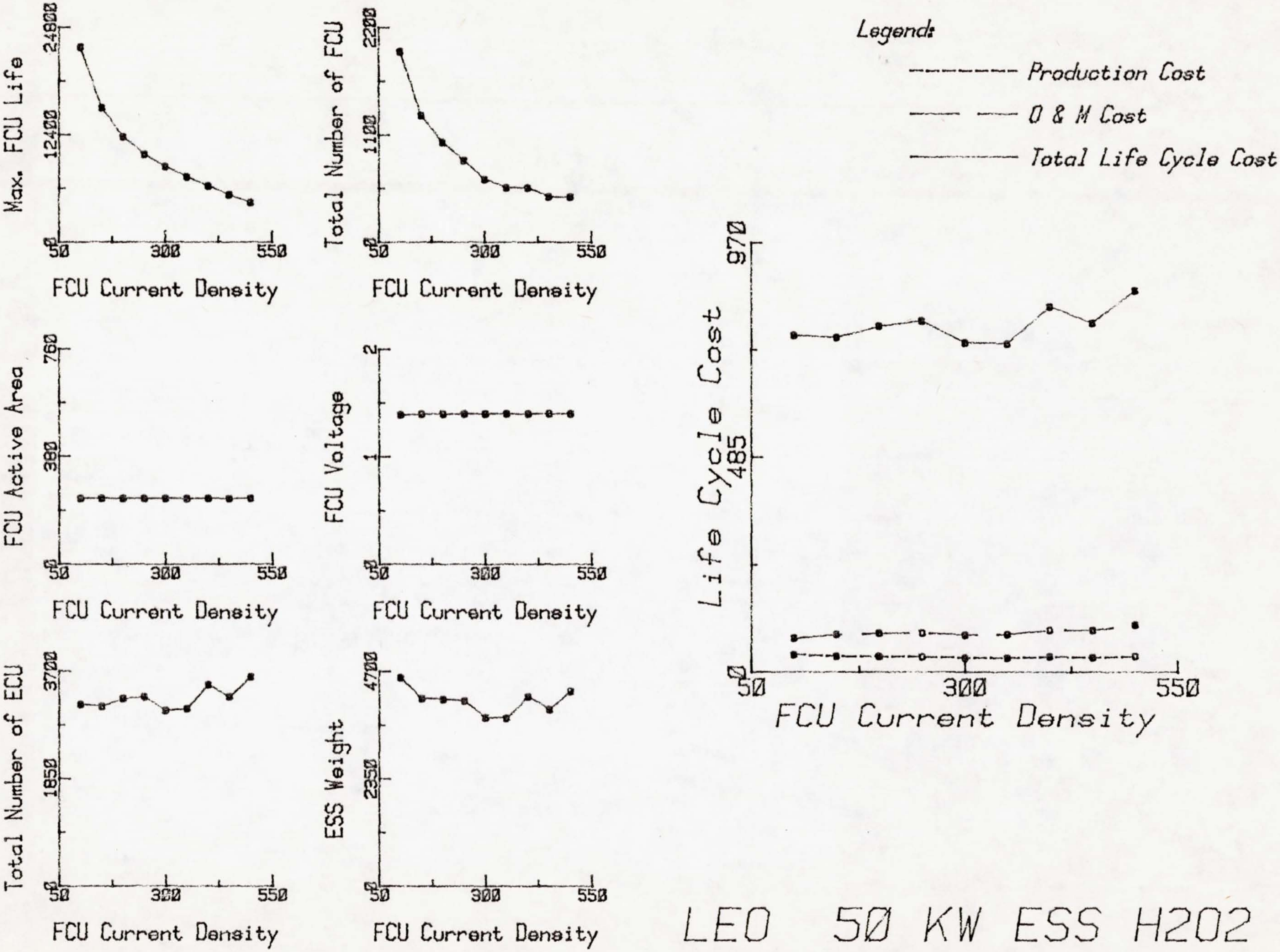

Exhibit 17b. FCU Current Density (Continued)

LEO 100KW ESS (H2O2)

EOL FCU PERFORMANCE									
Hardware Life Cycles	3	5	6	7	8	9	10	12	14
Maximum FCU Life (Hr)	22537	15506	12177	10125	8742	7530	6451	5455	4551
Dark Period Power (W)	32.31	48.74	64.97	81.26	97.55	113.80	130.04	146.30	162.52
Dark Period Voltage (V)	1.391	1.399	1.399	1.400	1.400	1.400	1.400	1.400	1.400
Active Cell Area (cm2)	232.26	232.26	232.26	232.26	232.26	232.26	232.26	232.26	232.26
Current Density (Ma/cm2)	100.00	150.00	200.00	250.00	300.00	350.00	400.00	450.00	500.00
Operating Pressure (Kg/cm2)	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125
Operating Temperature (Deg-K)	355	355	355	355	355	355	355	355	355
EOL ECU PERFORMANCE									
Light Period Power (W)	34.49	34.38	34.66	34.66	34.86	34.25	34.41	34.52	34.60
Light Period Voltage (V)	3.458	3.448	3.478	3.488	3.499	3.445	3.455	3.466	3.476
EOL SUBSYSTEM PERFORMANCE									
Hardware Life Cycles	4	4	4	4	4	4	4	4	4
Maximum Pump Life (Hr)	62393	62393	62393	62393	62393	62393	62393	62393	62393
H2 Storage Weight (Kg)	5.509	5.445	5.413	5.458	5.323	5.371	5.620	5.742	5.737
DoD Factor	.800	.800	.800	.800	.800	.800	.800	.800	.800
Watt-Hour Efficiency	.404	.412	.411	.411	.411	.418	.417	.417	.416
PHYSICAL CHARACTERISTICS									
Total Number of FCU	3906	2604	1953	1581	1288	1116	1023	930	837
Total Number of ECU	6222	6154	6120	6188	6018	6086	6358	6494	6494
ESS Weight (Kg)	9076	8190	7789	7645	7326	7297	7579	7692	7657
ESS Volume (M^3)	48.453	43.251	43.251	43.251	37.501	38.048	48.453	43.251	43.251
LIFE CYCLE COSTS (1980$M)									
DDT&E Cost	38.221	34.657	32.854	32.039	30.704	30.409	31.117	31.301	31.035
Production Cost	71.934	64.953	61.506	60.022	57.423	56.925	58.523	59.016	58.551
Operations & Maintenance Cost	141.319	155.899	153.705	154.619	151.116	152.763	159.186	168.625	174.173
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ESS LIFE CYCLE COST	251.474	255.509	248.065	246.680	239.243	240.097	248.826	258.942	263.759
Solar Array Cost	1061.115	1048.900	1051.118	1060.581	1042.004	1036.538	1077.566	1098.937	1100.854
Thermal Control Cost	8.437	8.528	8.905	9.319	9.528	9.882	10.385	10.793	11.065
Power Conditioning Cost	4.759	3.375	2.644	2.210	1.875	1.645	1.528	1.409	1.289
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TOTAL LIFE CYCLE COST	1325.785	1316.312	1310.732	1318.790	1292.650	1288.162	1338.305	1370.081	1376.967

Exhibit 17c. FCU Current Density

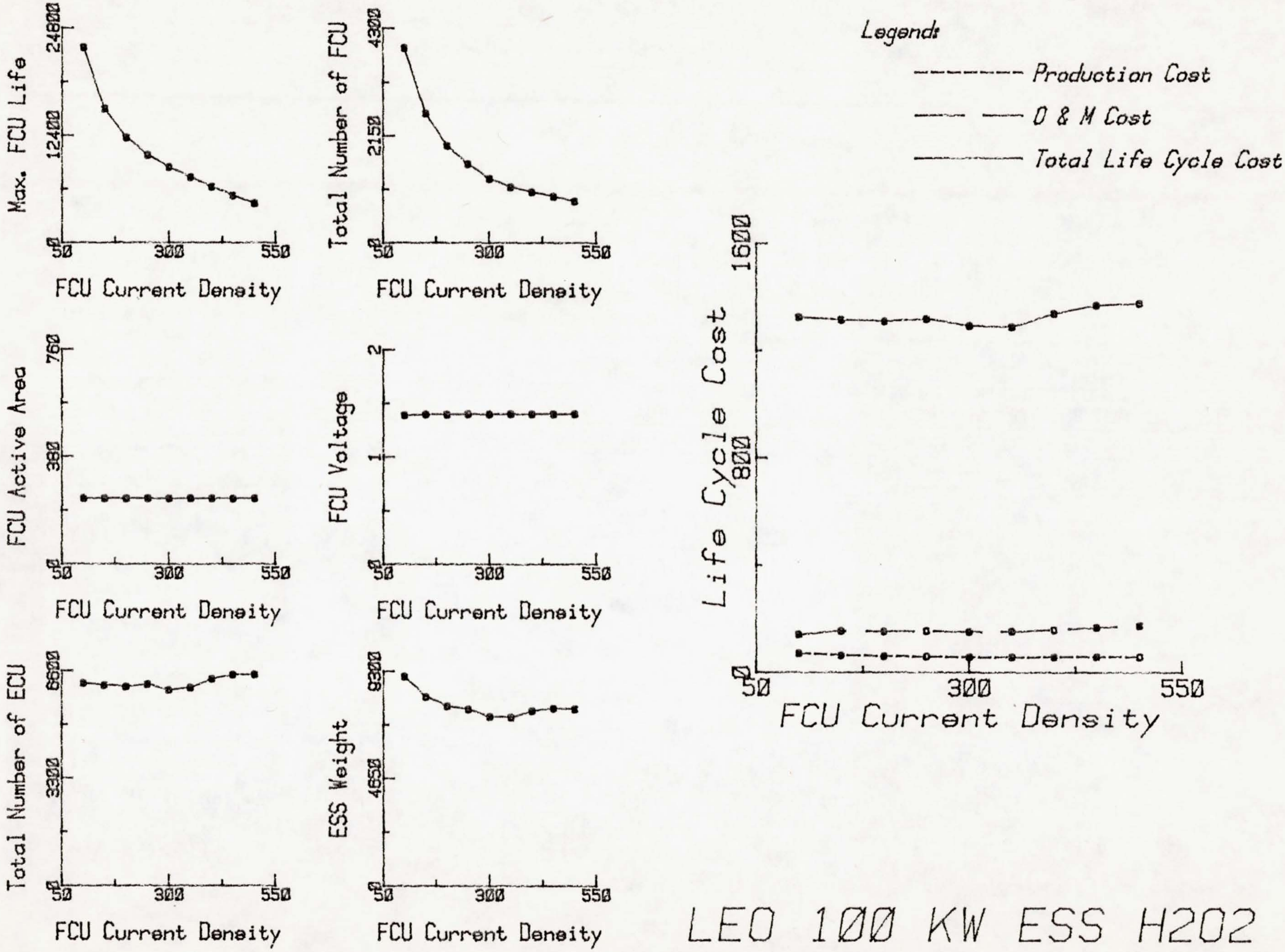

Exhibit 17c. FCU Current Density (Continued)

LEO 250KW ESS (H2O2)

EOL FCU PERFORMANCE									
Hardware Life Cycles	3	5	6	7	8	9	10	12	14
Maximum FCU Life (Hr)	22537	15506	12177	10125	8742	7530	6451	5455	4551
Dark Period Power (W)	32.31	48.74	64.97	81.26	97.55	113.80	130.04	146.30	162.52
Dark Period Voltage (V)	1.391	1.399	1.399	1.400	1.400	1.400	1.400	1.400	1.400
Active Cell Area (cm2)	232.26	232.26	232.26	232.26	232.26	232.26	232.26	232.26	232.26
Current Density (Ma/cm2)	100.00	150.00	200.00	250.00	300.00	350.00	400.00	450.00	500.00
Operating Pressure (Kg/cm2)	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125
Operating Temperature (Deg-K)	355	355	355	355	355	355	355	355	355
EOL ECU PERFORMANCE									
Light Period Power (W)	34.46	34.42	34.68	34.79	34.90	34.38	34.49	34.56	34.65
Light Period Voltage (V)	3.458	3.448	3.478	3.488	3.499	3.445	3.455	3.466	3.476
EOL SUBSYSTEM PERFORMANCE									
Hardware Life Cycles	4	4	4	4	4	4	4	4	4
Maximum Pump Life (Hr)	62393	62393	62393	62393	62393	62393	62393	62393	62393
H2 Storage Weight (Kg)	13.774	13.613	13.661	13.484	13.306	13.429	13.794	13.781	13.386
DoD Factor	.800	.800	.800	.800	.800	.800	.800	.800	.800
Watt-Hour Efficiency	.404	.412	.411	.411	.411	.418	.417	.417	.416
PHYSICAL CHARACTERISTICS									
Total Number of FCU	9765	6510	4929	3906	3220	2790	2511	2232	1953
Total Number of ECU	15572	15368	15436	15232	15028	15164	15572	15572	15130
ESS Weight (Kg)	22656	20433	19614	18833	18261	18217	18537	18421	17812
ESS Volume (M^3)	115.260	99.103	93.900	93.900	77.745	88.697	115.260	99.103	93.900
LIFE CYCLE COSTS (1980$M)									
DDT&E Cost	62.098	55.840	53.123	50.728	48.929	48.460	48.865	48.313	46.698
Production Cost	163.086	146.699	139.855	133.697	129.093	128.099	129.515	128.218	123.893
Operations & Maintenance Cost	321.540	352.711	349.764	343.833	339.014	341.583	350.038	362.734	364.126
	--------	--------	--------	--------	--------	--------	--------	--------	--------
ESS LIFE CYCLE COST	546.724	555.250	542.742	528.258	517.036	518.142	528.418	539.265	534.717
Solar Array Cost	2214.650	2189.311	2210.676	2192.866	2174.783	2163.704	2216.243	2219.765	2173.778
Thermal Control Cost	13.289	13.518	14.550	15.375	16.018	16.906	17.925	18.624	18.884
Power Conditioning Cost	10.351	7.340	5.797	4.759	4.078	3.578	3.272	2.961	2.644
	--------	--------	--------	--------	--------	--------	--------	--------	--------
TOTAL LIFE CYCLE COST	2785.014	2765.419	2773.765	2741.258	2711.915	2702.330	2765.858	2780.615	2730.023

Exhibit 17d. FCU Current Density

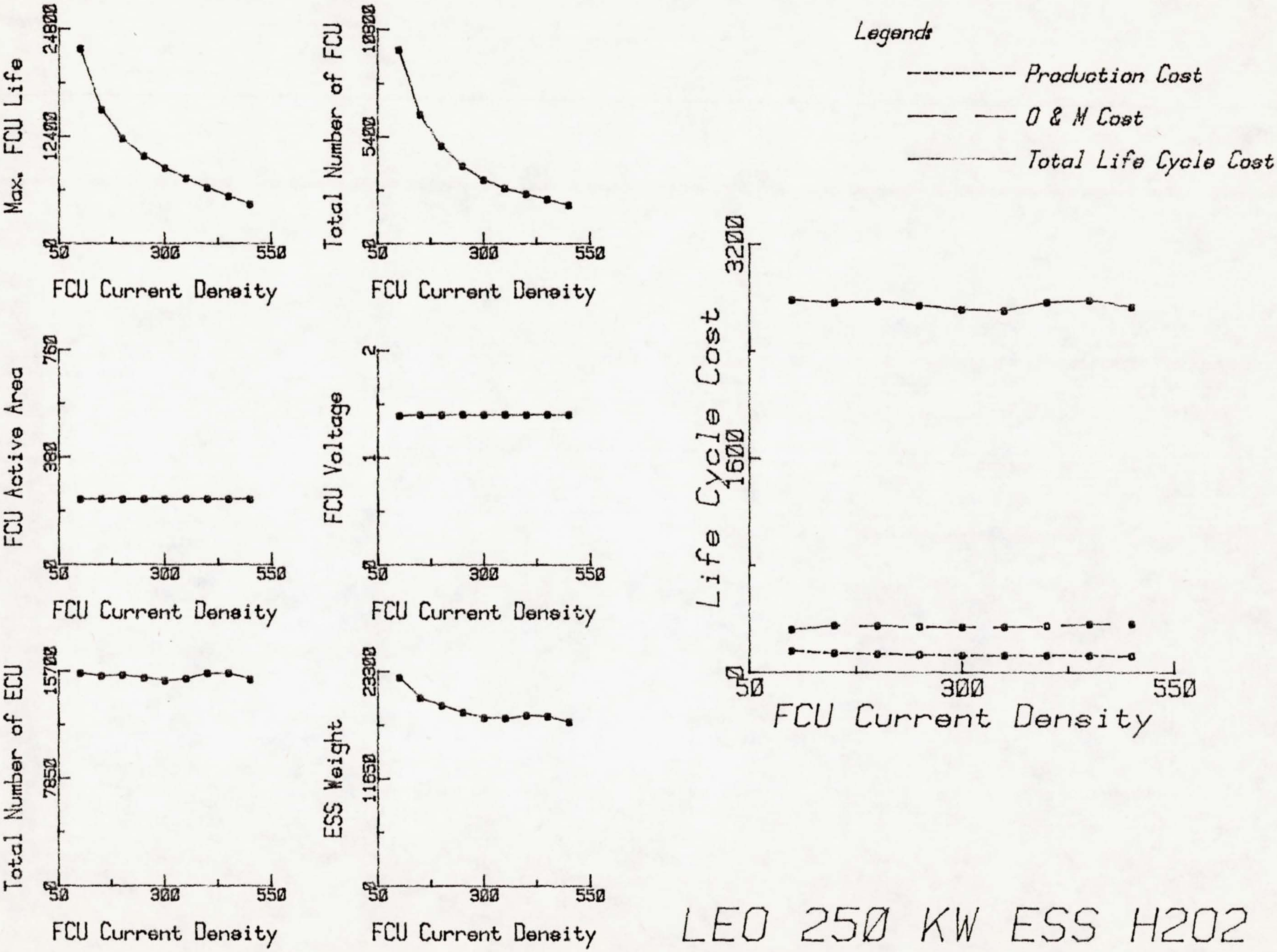

Exhibit 17d. FCU Current Density (Continued)

GEO 25KW ESS (H202)

EOL FCU PERFORMANCE									
Hardware Life Cycles	1	1	1	1	1	1	1	1	1
Maximum FCU Life (Hr)	22537	15506	12177	10125	8742	7530	6451	5455	4551
Dark Period Power (W)	32.31	48.74	64.97	81.26	97.55	113.80	130.04	146.30	162.52
Dark Period Voltage (V)	1.391	1.399	1.399	1.400	1.400	1.400	1.400	1.400	1.400
Active Cell Area (cm2)	232.26	232.26	232.26	232.26	232.26	232.26	232.26	232.26	232.26
Current Density (Ma/cm2)	100.00	150.00	200.00	250.00	300.00	350.00	400.00	450.00	500.00
Operating Pressure (Kg/cm2)	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125
Operating Temperature (Deg-K)	355	355	355	355	355	355	355	355	355
EOL ECU PERFORMANCE									
Light Period Power (W)	188.24	159.97	172.61	173.13	160.27	137.68	155.26	172.89	190.61
Light Period Voltage (V)	3.501	3.496	3.514	3.520	3.526	3.494	3.500	3.506	3.512
EOL SUBSYSTEM PERFORMANCE									
Hardware Life Cycles	1	1	1	1	1	1	1	1	1
Maximum Pump Life (Hr)	10519	10519	10519	10519	10519	10519	10519	10519	10519
H2 Storage Weight (Kg)	3.906	3.325	3.570	3.574	3.303	2.864	3.224	3.583	3.943
DoD Factor	.800	.800	.800	.800	.800	.800	.800	.800	.800
Watt-Hour Efficiency	.268	.303	.321	.334	.342	.353	.357	.361	.364
PHYSICAL CHARACTERISTICS									
Total Number of FCU	1023	651	558	465	368	279	279	279	279
Total Number of ECU	34	34	34	34	34	34	34	34	34
ESS Weight (Kg)	1011	763	747	708	637	548	595	644	694
ESS Volume (M^3)	9.302	9.302	9.302	9.302	9.302	9.302	9.302	9.302	9.302
LIFE CYCLE COSTS (1980$M)									
DDT&E Cost	10.344	8.978	8.682	8.349	7.943	7.524	7.594	7.665	7.732
Production Cost	23.272	20.385	19.919	19.309	18.481	17.567	17.842	18.128	18.419
Operations & Maintenance Cost	.500	.500	.500	.500	.500	.500	.500	.500	.500
ESS LIFE CYCLE COST	34.116	29.863	29.101	28.158	26.924	25.591	25.936	26.293	26.651
Solar Array Cost	28.601	25.097	26.679	26.744	25.136	22.247	24.503	26.713	28.889
Thermal Control Cost	5.939	6.011	6.235	6.386	6.412	6.350	6.590	6.851	7.124
Power Conditioning Cost	1.166	1.042	1.166	1.289	1.166	1.042	1.166	1.289	1.409
TOTAL LIFE CYCLE COST	69.822	62.013	63.181	62.577	59.638	55.230	58.195	61.146	64.073

Exhibit 17e. FCU Current Density

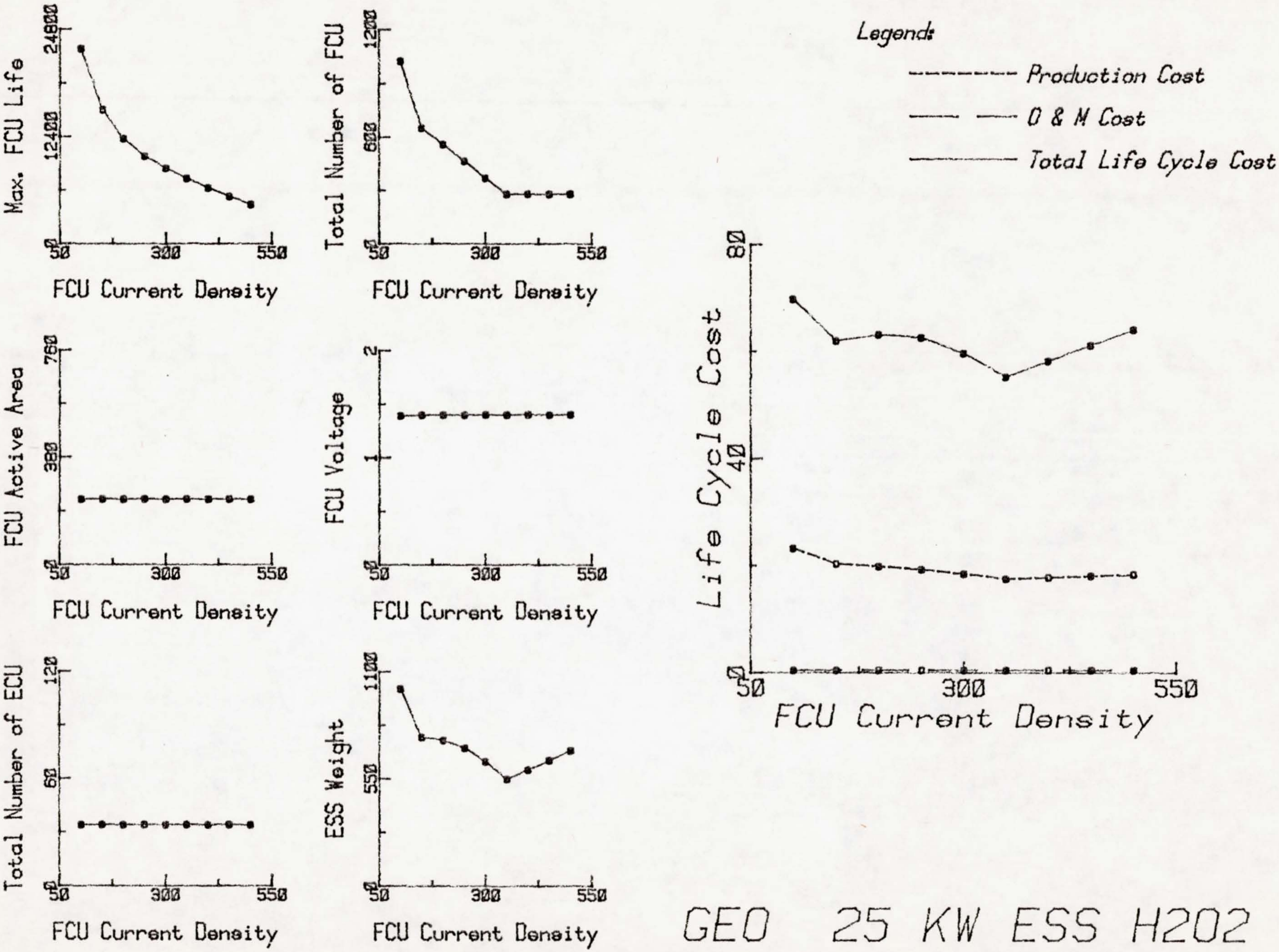

Exhibit 17e. FCU Current Density (Continued)

LEO 25KW ESS (H202)

EOL FCU PERFORMANCE									
Hardware Life Cycles	4	4	4	4	5	4	4	4	4
Maximum FCU Life (Hr)	15910	15910	15910	15910	15909	15910	15910	15910	15910
Dark Period Power (W)	89.19	71.42	58.12	47.24	38.98	29.94	21.61	11.22	8.32
Dark Period Voltage (V)	1.100	1.200	1.300	1.400	1.500	1.600	1.700	1.800	1.900
Active Cell Area (cm2)	232.26	232.26	232.26	232.26	232.26	232.26	232.26	232.26	232.26
Current Density (Ma/cm2)	349.09	256.26	192.48	145.29	111.87	80.56	54.74	26.85	18.86
Operating Pressure (Kg/cm2)	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125
Operating Temperature (Deg-K)	355	355	355	355	355	355	355	355	355
EOL ECU PERFORMANCE									
Light Period Power (W)	34.01	34.58	34.05	33.97	34.59	34.03	33.69	34.65	34.50
Light Period Voltage (V)	3.444	3.498	3.467	3.437	3.475	3.493	3.454	3.501	3.482
EOL SUBSYSTEM PERFORMANCE									
Hardware Life Cycles	4	4	4	4	4	4	4	4	4
Maximum Pump Life (Hr)	62393	62393	62393	62393	62393	62393	62393	62393	62393
H2 Storage Weight (Kg)	1.699	1.910	1.602	1.492	1.352	1.207	1.208	1.165	1.166
DoD Factor	.800	.800	.800	.800	.800	.800	.800	.800	.800
Watt-Hour Efficiency	.329	.352	.383	.413	.435	.456	.480	.471	.476
PHYSICAL CHARACTERISTICS									
Total Number of FCU	354	540	600	736	860	1053	1520	2808	3808
Total Number of ECU	1938	2176	1836	1700	1530	1394	1394	1326	1326
ESS Weight (Kg)	2311	2676	2343	2291	2182	2161	2462	3220	3853
ESS Volume (M^3)	15.051	20.254	15.051	15.051	15.051	15.051	15.051	20.254	15.051
LIFE CYCLE COSTS (1980$M)									
DDT&E Cost	16.824	18.588	17.343	17.280	16.925	16.988	18.555	22.324	25.305
Production Cost	22.083	25.025	22.830	22.658	22.015	22.063	24.630	30.880	35.896
Operations & Maintenance Cost	44.328	51.296	47.084	47.289	52.285	47.681	55.130	73.555	88.242
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ESS LIFE CYCLE COST	83.235	94.909	87.257	87.227	91.225	86.732	98.315	126.759	149.443
Solar Array Cost	411.208	457.364	394.094	369.792	344.759	315.778	313.202	307.727	306.660
Thermal Control Cost	6.681	6.658	6.284	6.098	5.992	5.915	5.929	5.942	5.972
Power Conditioning Cost	.508	.783	.914	1.166	1.409	1.761	2.537	4.469	6.074
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TOTAL LIFE CYCLE COST	501.632	559.714	488.549	464.283	443.385	410.186	419.983	444.897	468.149

Exhibit 18a. FCU Voltage

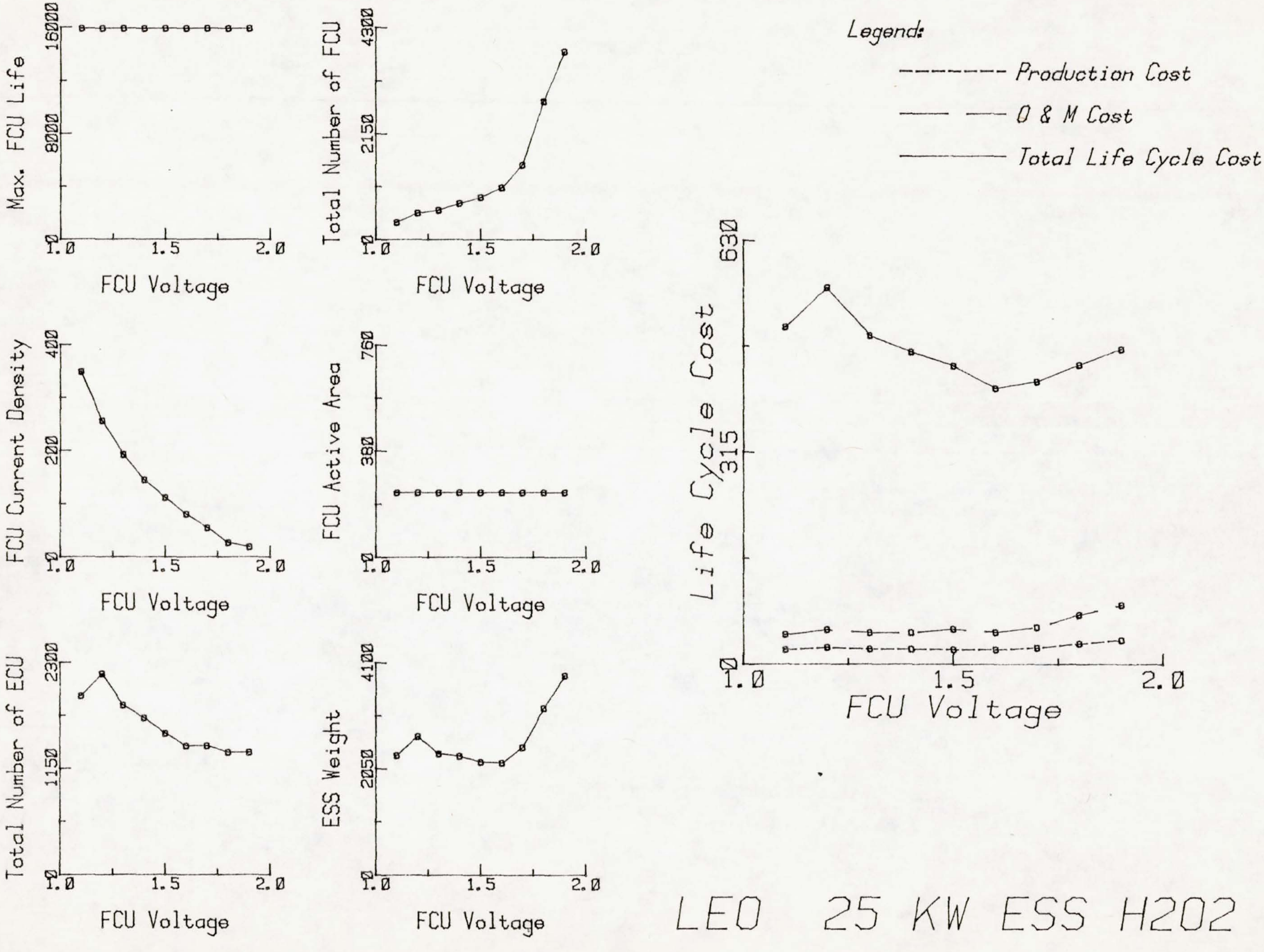

Exhibit 18a. FCU Voltage (Continued)

LEO 50KW ESS (H2O2)

EOL FCU PERFORMANCE									
Hardware Life Cycles	4	4	4	4	5	4	4	4	4
Maximum FCU Life (Hr)	15910	15910	15910	15910	15909	15910	15910	15910	15910
Dark Period Power (W)	89.19	71.42	58.12	47.24	38.98	29.94	21.61	11.22	8.32
Dark Period Voltage (V)	1.100	1.200	1.300	1.400	1.500	1.600	1.700	1.800	1.900
Active Cell Area (cm2)	232.26	232.26	232.26	232.26	232.26	232.26	232.26	232.26	232.26
Current Density (Ma/cm2)	349.09	256.26	192.48	145.29	111.87	80.56	54.74	26.85	18.86
Operating Pressure (Kg/cm2)	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125
Operating Temperature (Deg-K)	355	355	355	355	355	355	355	355	355
EOL ECU PERFORMANCE									
Light Period Power (W)	34.33	34.65	34.41	34.26	34.38	34.47	34.11	34.65	34.64
Light Period Voltage (V)	3.444	3.498	3.467	3.437	3.475	3.493	3.454	3.501	3.482
EOL SUBSYSTEM PERFORMANCE									
Hardware Life Cycles	4	4	4	4	4	4	4	4	4
Maximum Pump Life (Hr)	62393	62393	62393	62393	62393	62393	62393	62393	62393
H2 Storage Weight (Kg)	3.399	3.438	2.936	2.797	2.569	2.413	2.355	2.330	2.312
DoD Factor	.800	.800	.800	.800	.800	.800	.800	.800	.800
Watt-Hour Efficiency	.329	.352	.383	.413	.435	.456	.480	.471	.476
PHYSICAL CHARACTERISTICS									
Total Number of FCU	708	972	1100	1380	1634	2106	2964	5616	7548
Total Number of ECU	3842	3910	3332	3162	2924	2754	2686	2652	2618
ESS Weight (Kg)	4567	4776	4235	4245	4158	4270	4766	6410	7580
ESS Volume (M^3)	26.549	26.549	26.003	26.003	26.003	26.003	26.549	26.549	26.003
LIFE CYCLE COSTS (1980$M)									
DDT&E Cost	24.766	25.954	24.152	24.483	24.368	25.121	27.497	34.910	39.983
Production Cost	38.098	40.061	36.675	37.133	36.820	38.026	42.087	54.911	63.751
Operations & Maintenance Cost	78.979	84.377	78.019	80.015	89.978	85.191	97.021	134.297	160.510
	--------	--------	--------	--------	--------	--------	--------	--------	--------
ESS LIFE CYCLE COST	141.843	150.392	138.846	141.631	151.166	148.338	166.605	224.118	264.244
Solar Array Cost	717.670	733.298	641.383	612.778	577.145	551.182	535.662	536.917	531.276
Thermal Control Cost	8.161	7.824	7.185	6.883	6.703	6.629	6.621	6.684	6.731
Power Conditioning Cost	.914	1.289	1.528	1.988	2.429	3.169	4.469	8.045	10.851
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TOTAL LIFE CYCLE COST	868.588	892.803	788.942	763.280	737.443	709.318	713.357	775.764	813.102

Exhibit 18b. FCU Voltage

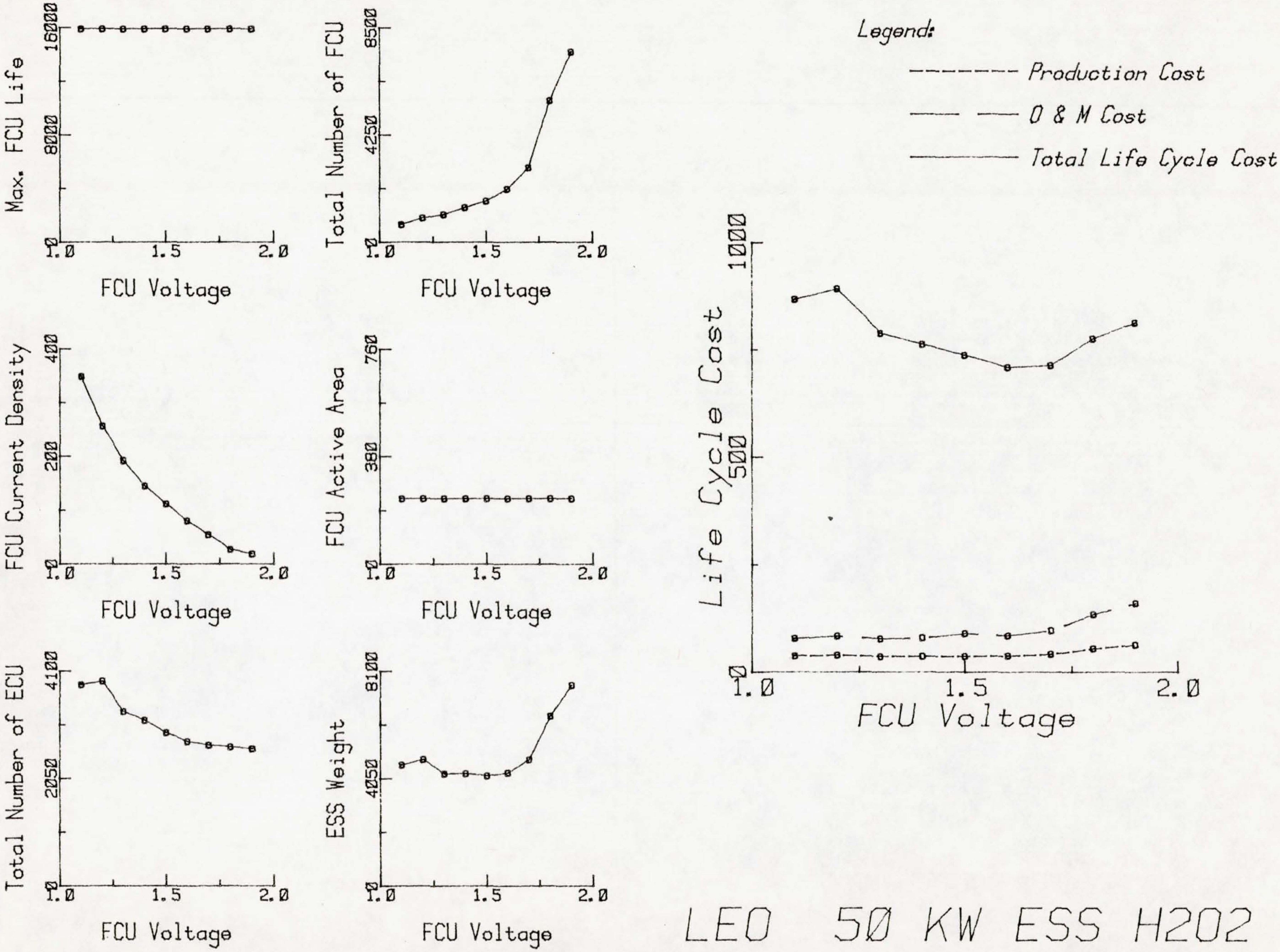

Exhibit 18b. FCU Voltage (Continued)

LEO 100KW ESS (H2O2)

EOL FCU PERFORMANCE									
Hardware Life Cycles	4	4	4	4	5	4	4	4	4
Maximum FCU Life (Hr)	15910	15910	15910	15910	15909	15910	15910	15910	15910
Dark Period Power (W)	89.19	71.42	58.12	47.24	38.98	29.94	21.61	11.22	8.32
Dark Period Voltage (V)	1.100	1.200	1.300	1.400	1.500	1.600	1.700	1.800	1.900
Active Cell Area (cm2)	232.26	232.26	232.26	232.26	232.26	232.26	232.26	232.26	232.26
Current Density (Ma/cm2)	349.09	256.26	192.48	145.29	111.87	80.56	54.74	26.85	18.86
Operating Pressure (Kg/cm2)	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125
Operating Temperature (Deg-K)	355	355	355	355	355	355	355	355	355
EOL ECU PERFORMANCE									
Light Period Power (W)	34.32	34.85	34.60	34.22	34.59	34.69	34.33	34.88	34.64
Light Period Voltage (V)	3.444	3.498	3.467	3.437	3.475	3.493	3.454	3.501	3.482
EOL SUBSYSTEM PERFORMANCE									
Hardware Life Cycles	4	4	4	4	4	4	4	4	4
Maximum Pump Life (Hr)	62393	62393	62393	62393	62393	62393	62393	62393	62393
H2 Storage Weight (Kg)	6.798	6.494	5.872	5.408	5.137	4.827	4.650	4.661	4.624
DoD Factor	.800	.800	.800	.800	.800	.800	.800	.800	.800
Watt-Hour Efficiency	.329	.352	.383	.413	.435	.456	.480	.471	.476
PHYSICAL CHARACTERISTICS									
Total Number of FCU	1416	1836	2200	2668	3268	4212	5852	11232	15096
Total Number of ECU	7684	7344	6630	6120	5814	5474	5270	5270	5236
ESS Weight (Kg)	9104	8982	8443	8201	8263	8513	9372	12767	15153
ESS Volume (M^3)	49.000	49.000	43.251	37.501	42.704	42.704	49.000	49.000	43.251
LIFE CYCLE COSTS (1980$M)									
DDT&E Cost	36.041	36.249	35.043	34.727	35.348	36.666	40.140	52.809	61.432
Production Cost	68.773	68.845	66.015	65.081	66.118	68.551	75.334	100.474	117.645
Operations & Maintenance Cost	144.661	146.568	142.296	142.254	164.120	155.714	175.945	248.193	298.212
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ESS LIFE CYCLE COST	249.475	251.662	243.354	242.062	265.586	260.931	291.419	401.476	477.289
Solar Array Cost	1252.091	1222.177	1119.261	1040.371	1007.166	961.836	925.100	936.937	926.942
Thermal Control Cost	11.119	10.156	9.169	8.454	8.207	8.058	8.005	8.168	8.261
Power Conditioning Cost	1.645	2.210	2.750	3.477	4.372	5.704	7.957	14.481	19.532
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TOTAL LIFE CYCLE COST	1514.330	1486.205	1374.534	1294.364	1285.331	1236.529	1232.481	1361.062	1432.024

Exhibit 18c. FCU Voltage

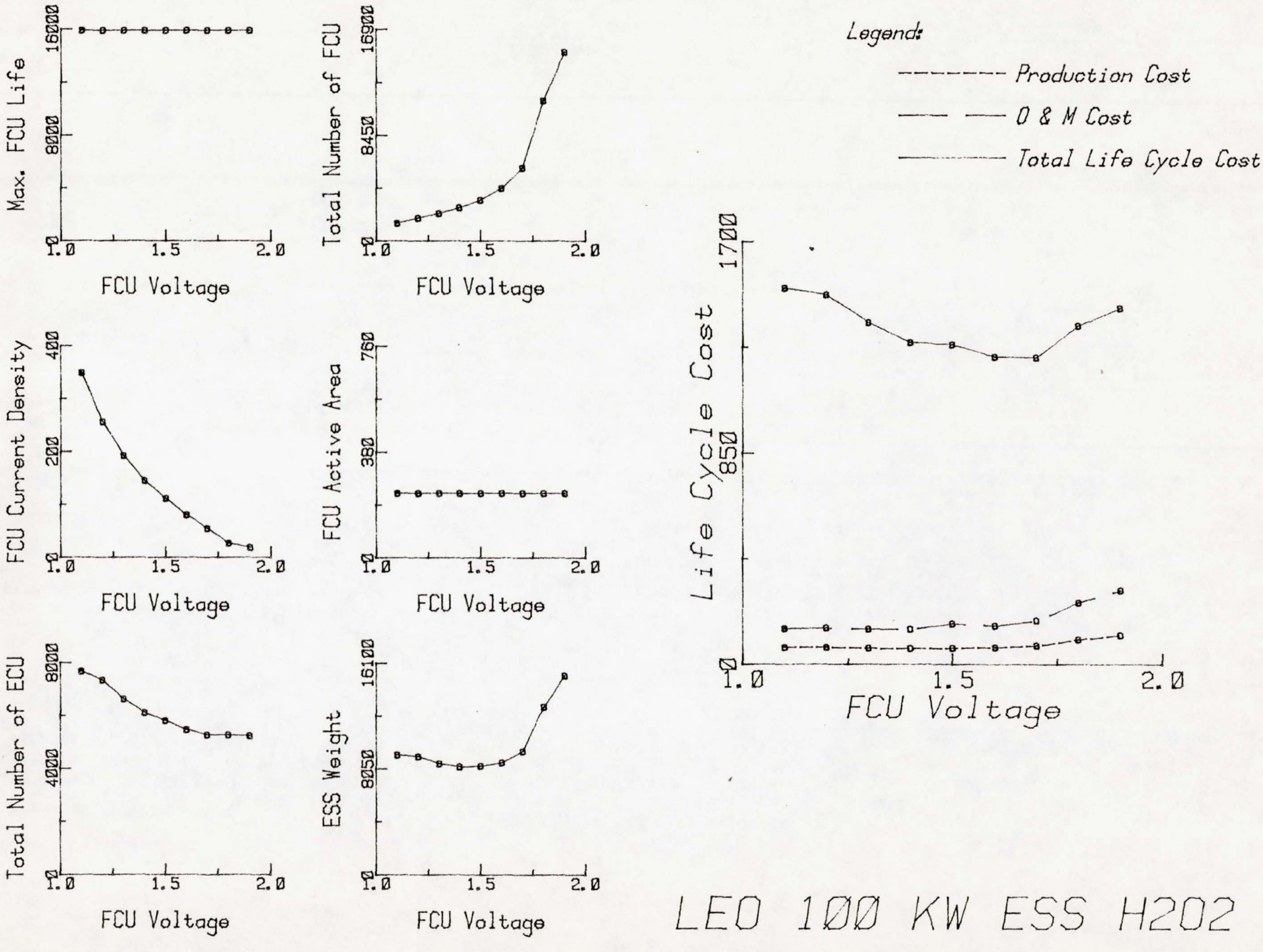

Exhibit 18c. FCU Voltage (Continued)

LEO 250KW ESS (H2O2)

EOL FCU PERFORMANCE									
Hardware Life Cycles	4	4	4	4	5	4	4	4	4
Maximum FCU Life (Hr)	15910	15910	15910	15910	15909	15910	15910	15910	15910
Dark Period Power (W)	89.19	71.42	58.12	47.24	38.98	29.94	21.61	11.22	8.32
Dark Period Voltage (V)	1.100	1.200	1.300	1.400	1.500	1.600	1.700	1.800	1.900
Active Cell Area (cm2)	232.26	232.26	232.26	232.26	232.26	232.26	232.26	232.26	232.26
Current Density (Ma/cm2)	349.09	256.26	192.48	145.29	111.87	80.56	54.74	26.85	18.86
Operating Pressure (Kg/cm2)	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125
Operating Temperature (Deg-K)	355	355	355	355	355	355	355	355	355
EOL ECU PERFORMANCE									
Light Period Power (W)	34.32	34.91	34.56	34.29	34.68	34.83	34.47	34.93	34.76
Light Period Voltage (V)	3.444	3.498	3.467	3.437	3.475	3.493	3.454	3.501	3.482
EOL SUBSYSTEM PERFORMANCE									
Hardware Life Cycles	4	4	4	4	4	4	4	4	4
Maximum Pump Life (Hr)	62393	62393	62393	62393	62393	62393	62393	62393	62393
H2 Storage Weight (Kg)	16.994	15.663	14.680	13.426	12.708	12.067	11.534	11.622	11.539
DoD Factor	.800	.800	.800	.800	.800	.800	.800	.800	.800
Watt-Hour Efficiency	.329	.352	.383	.413	.435	.456	.480	.471	.476
PHYSICAL CHARACTERISTICS									
Total Number of FCU	3540	4428	5500	6624	8084	10530	14516	28008	37672
Total Number of ECU	19210	17680	16592	15164	14348	13634	13022	13124	13022
ESS Weight (Kg)	22717	21623	21085	20306	20408	21245	23167	31788	37786
ESS Volume (M^3)	106.490	105.400	104.850	88.151	92.808	98.010	106.490	105.400	104.850
LIFE CYCLE COSTS (1980$M)									
DDT&E Cost	58.225	56.809	56.559	55.596	56.542	59.363	64.920	87.542	102.829
Production Cost	155.801	150.914	149.368	145.979	147.995	155.058	169.485	229.424	269.993
Operations & Maintenance Cost	328.326	321.630	322.831	320.033	367.850	352.810	396.771	566.408	682.613
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ESS LIFE CYCLE COST	542.352	529.353	528.758	521.608	572.387	567.231	631.176	883.374	1055.435
Solar Array Cost	2613.233	2478.379	2335.866	2159.471	2084.376	2007.703	1918.986	1951.544	1932.017
Thermal Control Cost	20.000	17.151	15.120	13.277	12.637	12.344	12.160	12.603	12.838
Power Conditioning Cost	3.578	4.663	5.982	7.517	9.424	12.407	17.193	31.427	42.416
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TOTAL LIFE CYCLE COST	3179.163	3029.546	2885.726	2701.873	2678.824	2599.685	2579.515	2878.948	3042.706

Exhibit 18d. FCU Voltage

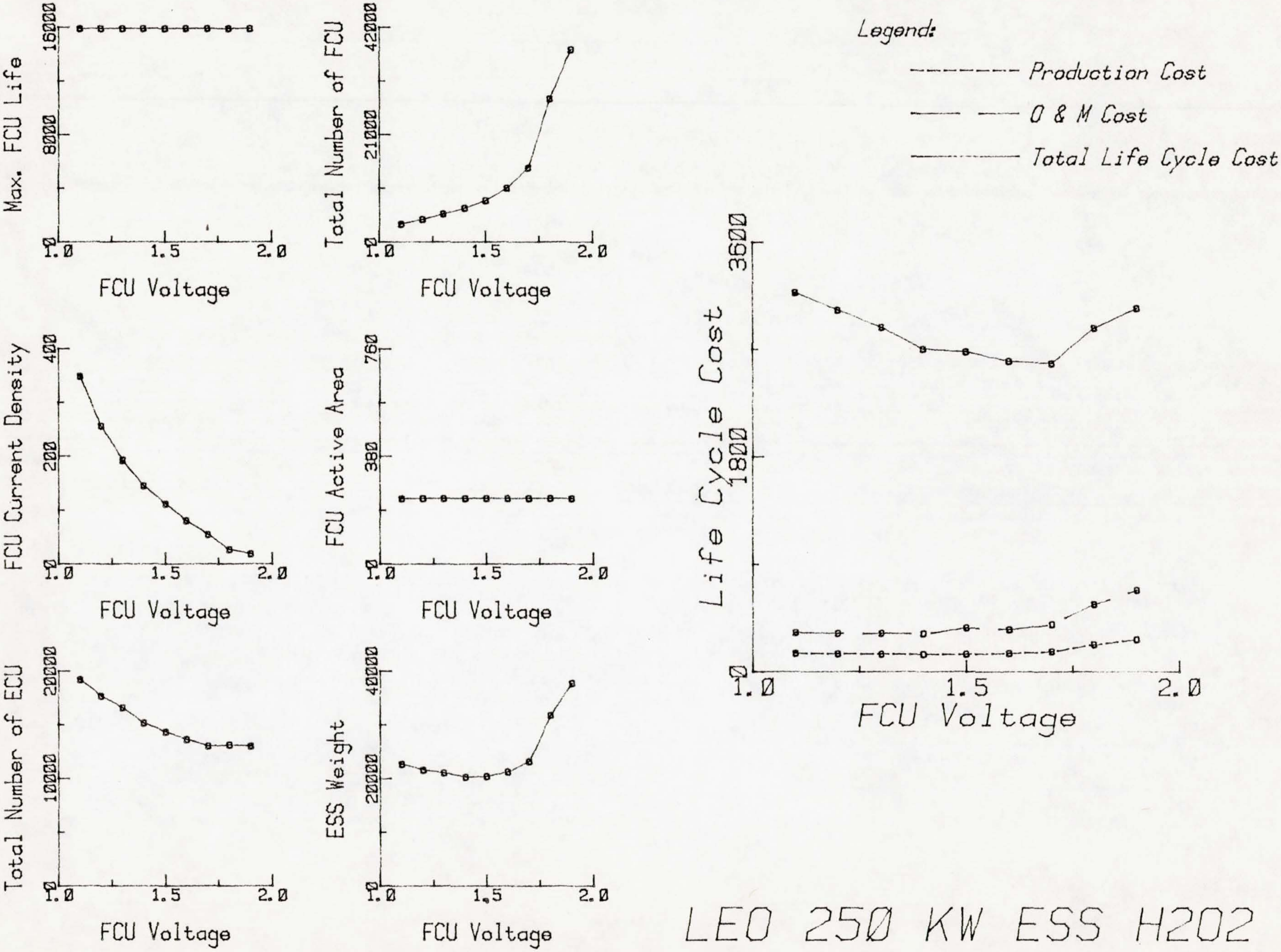

Exhibit 18d. FCU Voltage (Continued)

GEO 25KW ESS (H2O2)

EOL FCU PERFORMANCE									
Hardware Life Cycles	1	1	1	1	1	1	1	1	1
Maximum FCU Life (Hr)	10161	7939	5717	3496	1274	408	408	408	408
Dark Period Power (W)	145.38	158.59	171.81	185.02	198.24	166.54	110.27	61.84	25.49
Dark Period Voltage (V)	1.100	1.200	1.300	1.400	1.500	1.600	1.700	1.800	1.900
Active Cell Area (cm2)	232.26	232.26	232.26	232.26	232.26	232.26	232.26	232.26	232.26
Current Density (Ma/cm2)	569.00	569.00	569.00	569.00	569.00	448.18	279.27	147.93	57.76
Operating Pressure (Kg/cm2)	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125
Operating Temperature (Deg-K)	355	355	355	355	355	355	355	355	355
EOL ECU PERFORMANCE									
Light Period Power (W)	180.73	165.41	153.15	140.88	131.69	149.94	123.84	139.93	169.95
Light Period Voltage (V)	3.497	3.497	3.497	3.497	3.497	3.504	3.507	3.493	3.502
EOL SUBSYSTEM PERFORMANCE									
Hardware Life Cycles	1	1	1	1	1	1	1	1	1
Maximum Pump Life (Hr)	10519	10519	10519	10519	10519	10519	10519	10519	10519
H2 Storage Weight (Kg)	3.755	3.437	3.132	2.928	2.737	3.109	2.566	2.911	3.526
DoD Factor	.800	.800	.800	.800	.800	.800	.800	.800	.800
Watt-Hour Efficiency	.290	.317	.343	.369	.396	.413	.414	.389	.296
PHYSICAL CHARACTERISTICS									
Total Number of FCU	236	216	200	184	172	243	304	576	1292
Total Number of ECU	34	34	34	34	34	34	34	34	34
ESS Weight (Kg)	623	589	561	533	512	590	543	712	1144
ESS Volume (M^3)	9.302	9.302	9.302	9.302	9.302	9.302	9.302	9.302	9.302
LIFE CYCLE COSTS (1980$M)									
DDT&E Cost	7.468	7.358	7.266	7.175	7.105	7.478	7.609	8.701	11.246
Production Cost	17.779	17.498	17.270	17.040	16.867	17.664	17.666	19.806	25.750
Operations & Maintenance Cost	.500	.500	.500	.500	.500	.500	.500	.500	.500
ESS LIFE CYCLE COST	25.747	25.356	25.036	24.715	24.472	25.642	25.775	29.007	37.496
Solar Array Cost	27.681	25.781	24.235	22.663	21.469	23.825	20.433	22.539	26.348
Thermal Control Cost	7.163	6.996	6.863	6.730	6.630	6.629	6.108	5.903	5.637
Power Conditioning Cost	1.166	1.166	1.166	1.166	1.166	1.289	1.166	1.166	1.166
TOTAL LIFE CYCLE COST	61.757	59.299	57.300	55.274	53.737	57.385	53.482	58.615	70.647

Exhibit 18e. FCU Voltage

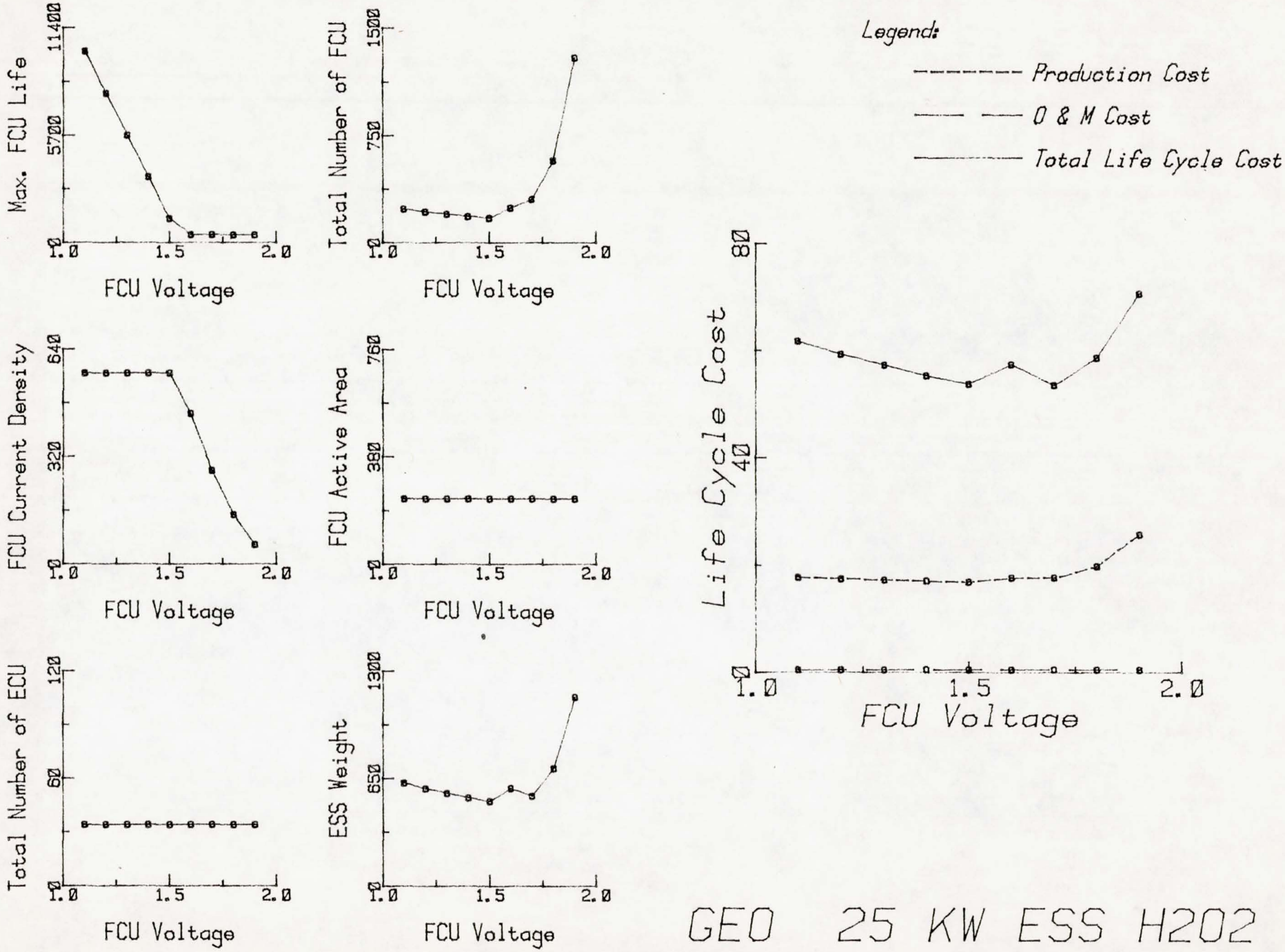

Exhibit 18e. FCU Voltage (Continued)

LEO 25KW ESS (H202)

EOL FCU PERFORMANCE									
Hardware Life Cycles	4	4	4	4	4	4	4	4	4
Maximum FCU Life (Hr)	16013	17004	16013	17004	17004	16013	13069	20460	17004
Dark Period Power (W)	24.28	34.57	48.56	57.62	69.14	84.97	87.79	90.33	115.23
Dark Period Voltage (V)	1.403	1.427	1.403	1.427	1.427	1.403	1.449	1.491	1.427
Active Cell Area (cm2)	120.00	180.00	240.00	300.00	360.00	420.00	480.00	540.00	600.00
Current Density (Ma/cm2)	144.25	134.63	144.25	134.63	134.63	144.25	126.22	112.19	134.63
Operating Pressure (Kg/cm2)	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125
Operating Temperature (Deg-K)	355	355	355	355	355	355	355	355	355
EOL ECU PERFORMANCE									
Light Period Power (W)	34.48	33.78	34.48	33.78	33.78	34.48	34.21	34.14	33.78
Light Period Voltage (V)	3.497	3.459	3.497	3.459	3.459	3.497	3.496	3.476	3.459
EOL SUBSYSTEM PERFORMANCE									
Hardware Life Cycles	4	4	4	4	4	4	4	4	4
Maximum Pump Life (Hr)	62393	62393	62393	62393	62393	62393	62393	62393	62393
H2 Storage Weight (Kg)	1.340	1.327	1.340	1.327	1.327	1.339	1.300	1.276	1.327
DoD Factor	.800	.800	.800	.800	.800	.800	.800	.800	.800
Watt-Hour Efficiency	.407	.418	.407	.418	.418	.407	.419	.432	.418
PHYSICAL CHARACTERISTICS									
Total Number of FCU	1288	910	644	546	455	368	356	348	273
Total Number of ECU	1530	1530	1530	1530	1530	1530	1496	1462	1530
ESS Weight (Kg)	2442	2200	2037	1971	1914	1863	1826	1796	1799
ESS Volume (M^3)	15.051	15.051	15.051	15.051	15.051	15.051	15.051	15.051	15.051
LIFE CYCLE COSTS (1980$M)									
DDT&E Cost	16.959	16.598	16.178	16.142	16.021	15.815	15.834	15.870	15.764
Production Cost	22.477	21.608	20.789	20.639	20.389	20.035	20.006	20.007	19.872
Operations & Maintenance Cost	47.306	45.383	43.277	43.050	42.442	41.451	41.531	41.661	41.171
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ESS LIFE CYCLE COST	86.742	83.589	80.244	79.831	78.852	77.301	77.371	77.538	76.807
Solar Array Cost	343.903	338.259	343.903	338.259	338.224	343.874	335.632	328.960	338.259
Thermal Control Cost	6.004	5.976	6.004	5.976	5.976	6.004	5.958	5.946	5.976
Power Conditioning Cost	1.875	1.409	1.042	.914	.783	.648	.648	.648	.508
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TOTAL LIFE CYCLE COST	438.524	429.233	431.193	424.980	423.835	427.827	419.609	413.092	421.550

Exhibit 19a. FCU Active Area

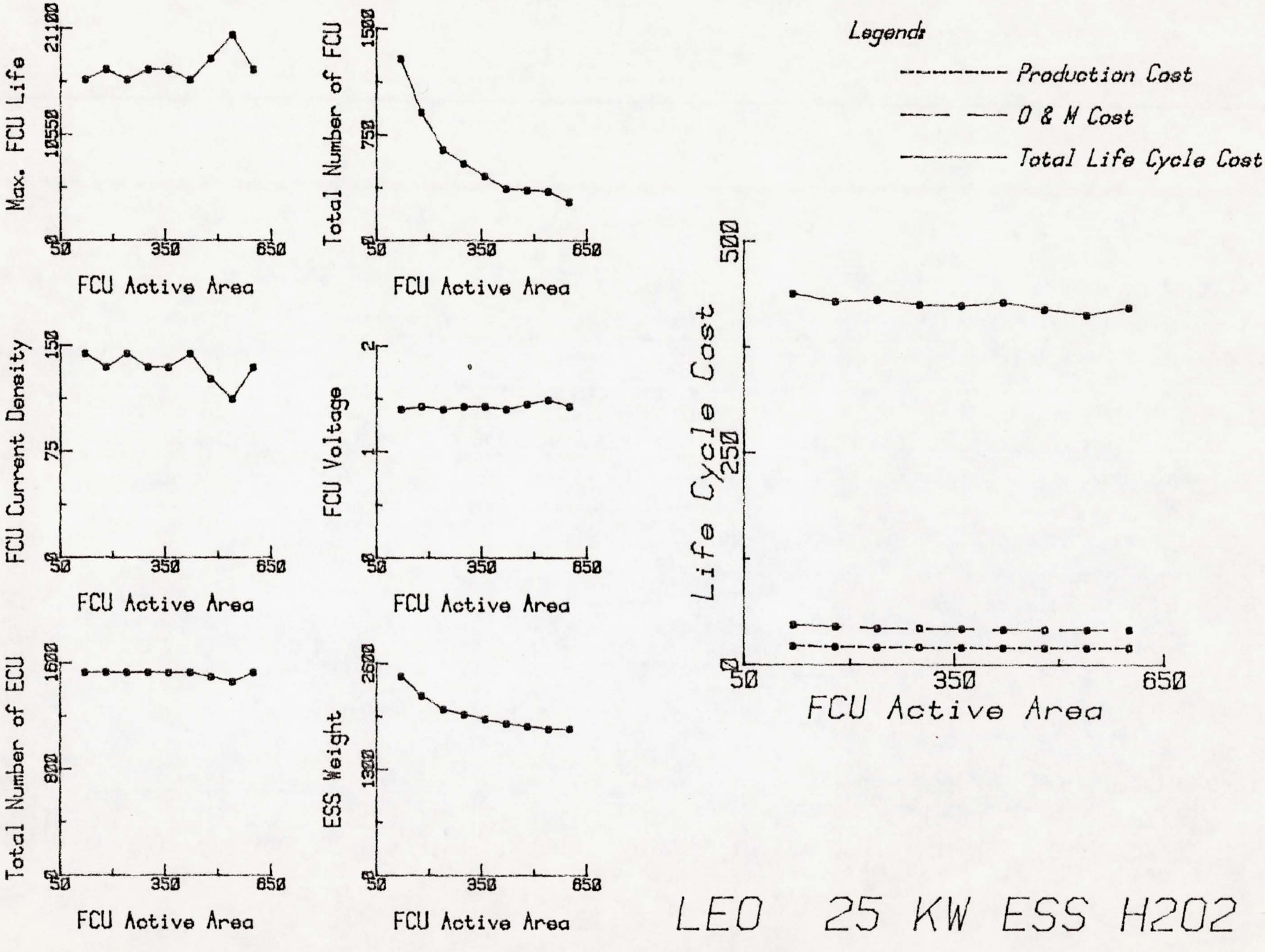

Exhibit 19a. FCU Active Area (Continued)

LEO 50KW ESS (H2O2)

EOL FCU PERFORMANCE									
Hardware Life Cycles	4	4	4	4	4	4	4	4	4
Maximum FCU Life (Hr)	16013	16274	16013	17003	17003	16013	16013	17728	17003
Dark Period Power (W)	24.28	35.94	48.56	57.62	69.14	84.97	97.11	99.92	115.24
Dark Period Voltage (V)	1.403	1.409	1.403	1.427	1.427	1.403	1.403	1.443	1.427
Active Cell Area (cm2)	120.00	180.00	240.00	300.00	360.00	420.00	480.00	540.00	600.00
Current Density (Ma/cm2)	144.25	141.72	144.25	134.64	134.64	144.25	144.25	128.22	134.64
Operating Pressure (Kg/cm2)	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125
Operating Temperature (Deg-K)	355	355	355	355	355	355	355	355	355
EOL ECU PERFORMANCE									
Light Period Power (W)	34.88	34.80	34.89	34.17	34.17	34.89	34.88	34.63	34.17
Light Period Voltage (V)	3.497	3.487	3.497	3.459	3.459	3.497	3.497	3.499	3.459
EOL SUBSYSTEM PERFORMANCE									
Hardware Life Cycles	4	4	4	4	4	4	4	4	4
Maximum Pump Life (Hr)	62393	62393	62393	62393	62393	62393	62393	62393	62393
H2 Storage Weight (Kg)	2.679	2.680	2.679	2.655	2.655	2.679	2.679	2.629	2.655
DoD Factor	.800	.800	.800	.800	.800	.800	.800	.800	.800
Watt-Hour Efficiency	.407	.410	.407	.418	.418	.407	.407	.417	.418
PHYSICAL CHARACTERISTICS									
Total Number of FCU	2576	1748	1288	1092	910	736	644	630	546
Total Number of ECU	3026	3026	3026	3026	3026	3026	3026	2992	3026
ESS Weight (Kg)	4856	4334	4046	3915	3801	3699	3641	3573	3572
ESS Volume (M^3)	26.003	26.003	20.800	20.800	20.800	20.800	26.003	26.003	20.800
LIFE CYCLE COSTS (1980$M)									
DDT&E Cost	25.145	24.304	23.738	23.676	23.463	23.088	22.973	23.033	23.005
Production Cost	39.134	37.059	35.779	35.459	34.967	34.285	34.028	33.983	33.947
Operations & Maintenance Cost	84.939	80.067	76.939	76.418	75.219	73.327	72.697	73.289	72.721
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ESS LIFE CYCLE COST	149.218	141.430	136.456	135.553	133.649	130.700	129.698	130.305	129.673
Solar Array Cost	600.217	599.004	600.238	590.374	590.374	600.238	600.217	591.296	590.374
Thermal Control Cost	6.807	6.792	6.807	6.749	6.749	6.807	6.807	6.732	6.749
Power Conditioning Cost	3.375	2.429	1.875	1.645	1.409	1.166	1.042	1.042	.914
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TOTAL LIFE CYCLE COST	759.617	749.655	745.376	734.321	732.181	738.911	737.764	729.375	727.710

Exhibit 19b. FCU Active Area

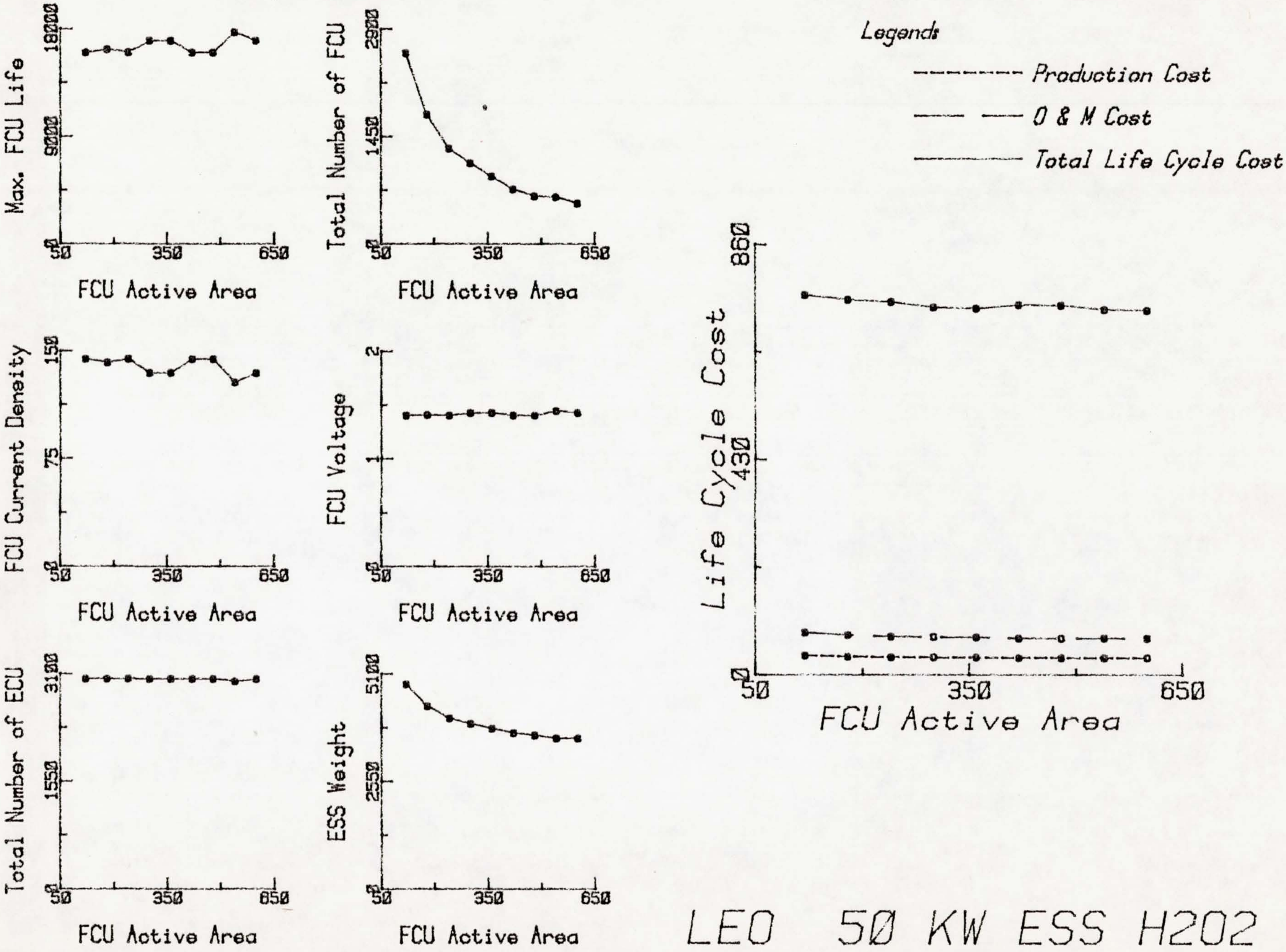

Exhibit 19b. FCU Active Area (Continued)

LEO 100KW ESS (H2O2)

EOL FCU PERFORMANCE									
Hardware Life Cycles	4	4	4	4	4	4	4	4	4
Maximum FCU Life (Hr)	16013	16274	16013	16401	16274	16013	16013	16648	17003
Dark Period Power (W)	24.28	35.94	48.56	59.51	71.88	84.97	97.11	105.73	115.24
Dark Period Voltage (V)	1.403	1.409	1.403	1.412	1.409	1.403	1.403	1.418	1.427
Active Cell Area (cm2)	120.00	180.00	240.00	300.00	360.00	420.00	480.00	540.00	600.00
Current Density (Ma/cm2)	144.25	141.72	144.25	140.49	141.72	144.25	144.25	138.09	134.64
Operating Pressure (Kg/cm2)	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125
Operating Temperature (Deg-K)	355	355	355	355	355	355	355	355	355
EOL ECU PERFORMANCE									
Light Period Power (W)	34.88	34.80	34.89	34.76	34.80	34.89	34.88	34.49	34.37
Light Period Voltage (V)	3.497	3.487	3.497	3.482	3.487	3.497	3.497	3.473	3.459
EOL SUBSYSTEM PERFORMANCE									
Hardware Life Cycles	4	4	4	4	4	4	4	4	4
Maximum Pump Life (Hr)	62393	62393	62393	62393	62393	62393	62393	62393	62393
H2 Storage Weight (Kg)	5.358	5.360	5.358	5.361	5.360	5.358	5.358	5.306	5.309
DoD Factor	.800	.800	.800	.800	.800	.800	.800	.800	.800
Watt-Hour Efficiency	.407	.410	.407	.411	.410	.407	.407	.414	.418
PHYSICAL CHARACTERISTICS									
Total Number of FCU	5152	3496	2576	2116	1748	1472	1288	1183	1092
Total Number of ECU	6052	6052	6052	6052	6052	6052	6052	6018	6018
ESS Weight (Kg)	9681	8638	8061	7768	7538	7366	7250	7149	7091
ESS Volume (M^3)	47.907	42.704	37.501	37.501	37.501	37.501	47.907	42.704	37.501
LIFE CYCLE COSTS (1980$M)									
DDT&E Cost	36.778	35.339	34.379	34.061	33.652	33.286	33.091	33.034	33.059
Production Cost	70.981	66.830	64.295	63.258	62.208	61.332	60.825	60.545	60.468
Operations & Maintenance Cost	156.581	146.833	140.681	138.350	135.757	133.537	132.299	131.817	131.754
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ESS LIFE CYCLE COST	264.340	249.002	239.355	235.669	231.617	228.155	226.215	225.396	225.281
Solar Array Cost	1047.221	1045.087	1047.270	1044.151	1045.087	1047.221	1047.221	1032.971	1030.202
Thermal Control Cost	8.412	8.384	8.412	8.371	8.384	8.412	8.412	8.317	8.298
Power Conditioning Cost	6.074	4.372	3.375	2.856	2.429	2.100	1.875	1.761	1.645
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TOTAL LIFE CYCLE COST	1326.047	1306.845	1298.412	1291.047	1287.517	1285.888	1283.723	1268.445	1265.426

Exhibit 19c. FCU Active Area

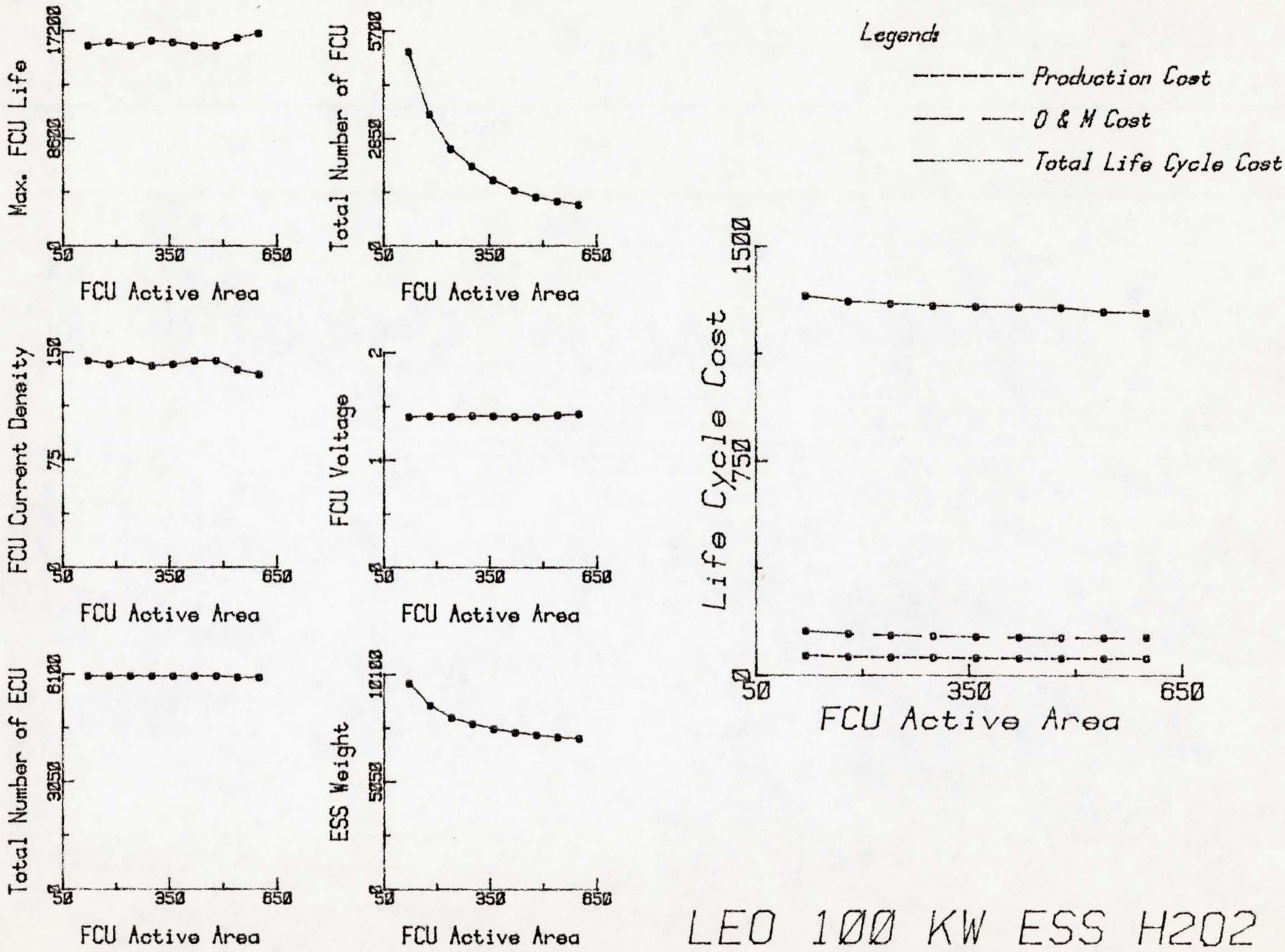

Exhibit 19c. FCU Active Area (Continued)

LEO 250KW ESS (H2O2)

EOL FCU PERFORMANCE									
Hardware Life Cycles	4	4	4	4	4	4	4	4	4
Maximum FCU Life (Hr)	16012	15960	16013	16012	16118	16012	16012	15960	16012
Dark Period Power (W)	24.28	36.51	48.56	60.70	72.45	84.98	97.11	109.54	121.39
Dark Period Voltage (V)	1.403	1.401	1.403	1.403	1.405	1.403	1.403	1.401	1.403
Active Cell Area (cm2)	120.00	180.00	240.00	300.00	360.00	420.00	480.00	540.00	600.00
Current Density (Ma/cm2)	144.26	144.77	144.25	144.26	143.23	144.26	144.26	144.77	144.26
Operating Pressure (Kg/cm2)	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125
Operating Temperature (Deg-K)	355	355	355	355	355	355	355	355	355
EOL ECU PERFORMANCE									
Light Period Power (W)	34.89	34.90	34.89	34.89	34.85	34.89	34.89	34.90	34.89
Light Period Voltage (V)	3.497	3.499	3.497	3.497	3.493	3.497	3.497	3.499	3.497
EOL SUBSYSTEM PERFORMANCE									
Hardware Life Cycles	4	4	4	4	4	4	4	4	4
Maximum Pump Life (Hr)	62393	62393	62393	62393	62393	62393	62393	62393	62393
H2 Storage Weight (Kg)	13.395	13.394	13.395	13.395	13.396	13.395	13.395	13.394	13.395
DoD Factor	.800	.800	.800	.800	.800	.800	.800	.800	.800
Watt-Hour Efficiency	.407	.406	.407	.407	.408	.407	.407	.406	.407
PHYSICAL CHARACTERISTICS									
Total Number of FCU	12880	8556	6440	5152	4324	3680	3220	2852	2576
Total Number of ECU	15130	15130	15130	15130	15130	15130	15130	15130	15130
ESS Weight (Kg)	24184	21465	20133	19323	18800	18397	18108	17878	17703
ESS Volume (M^3)	108.960	93.354	88.151	82.948	82.948	82.948	108.960	93.354	88.151
LIFE CYCLE COSTS (1980$M)									
DDT&E Cost	59.866	56.859	55.394	54.464	53.909	53.364	53.010	52.692	52.497
Production Cost	161.860	150.696	145.246	141.857	139.758	137.911	136.660	135.593	134.873
Operations & Maintenance Cost	358.083	331.606	318.677	310.564	305.603	301.059	298.020	295.379	293.654
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ESS LIFE CYCLE COST	579.809	539.161	519.317	506.885	499.270	492.334	487.690	483.664	481.024
Solar Array Cost	2185.727	2186.536	2185.727	2185.727	2183.815	2185.727	2185.727	2186.536	2185.727
Thermal Control Cost	13.229	13.242	13.228	13.229	13.200	13.229	13.229	13.242	13.229
Power Conditioning Cost	13.211	9.339	7.340	6.074	5.236	4.566	4.078	3.679	3.375
	--------	--------	--------	--------	--------	--------	--------	--------	--------
TOTAL LIFE CYCLE COST	2791.976	2748.278	2725.612	2711.915	2701.521	2695.856	2690.724	2687.121	2683.355

Exhibit 19d. FCU Active Area

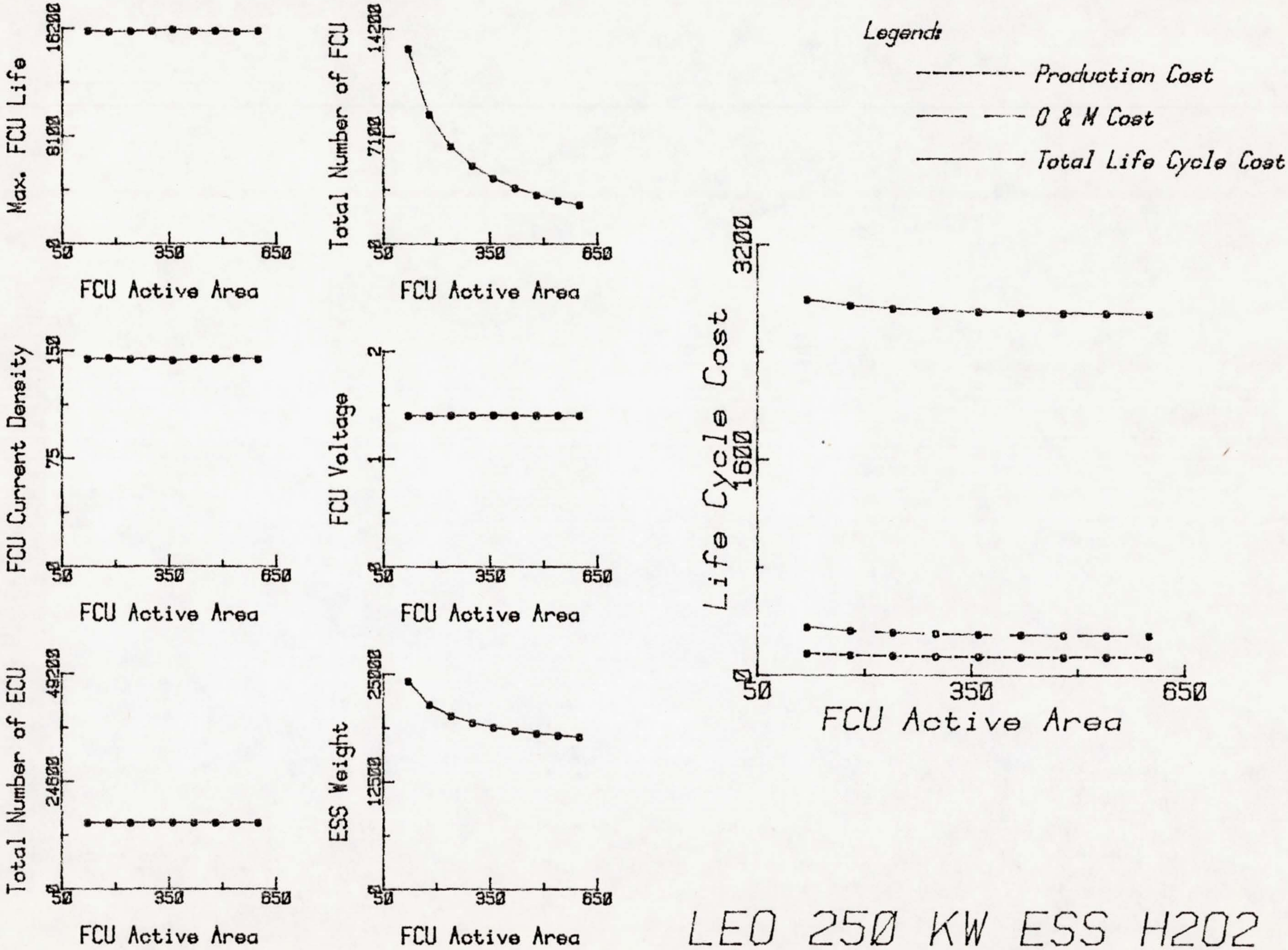

Exhibit 19d. FCU Active Area (Continued)

GEO 25KW ESS (H2O2)

EOL FCU PERFORMANCE									
Hardware Life Cycles	1	1	1	1	1	1	1	1	1
Maximum FCU Life (Hr)	4462	5476	4462	6368	7844	9040	4462	5476	6368
Dark Period Power (W)	95.14	129.21	190.27	196.79	201.59	205.20	380.55	387.62	393.58
Dark Period Voltage (V)	1.570	1.600	1.570	1.624	1.664	1.694	1.570	1.600	1.624
Active Cell Area (cm2)	120.00	180.00	240.00	300.00	360.00	420.00	480.00	540.00	600.00
Current Density (Ma/cm2)	504.88	448.78	504.88	403.90	336.58	288.50	504.88	448.78	403.90
Operating Pressure (Kg/cm2)	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125
Operating Temperature (Deg-K)	355	355	355	355	355	355	355	355	355
EOL ECU PERFORMANCE									
Light Period Power (W)	118.33	116.35	118.33	116.09	116.15	116.91	118.33	116.35	116.10
Light Period Voltage (V)	3.517	3.505	3.517	3.503	3.520	3.516	3.517	3.505	3.503
EOL SUBSYSTEM PERFORMANCE									
Hardware Life Cycles	1	1	1	1	1	1	1	1	1
Maximum Pump Life (Hr)	10519	10519	10519	10519	10519	10519	10519	10519	10519
H2 Storage Weight (Kg)	2.446	2.413	2.446	2.408	2.398	2.417	2.446	2.413	2.409
DoD Factor	.800	.800	.800	.800	.800	.800	.800	.800	.800
Watt-Hour Efficiency	.408	.413	.408	.415	.414	.413	.408	.413	.415
PHYSICAL CHARACTERISTICS									
Total Number of FCU	332	243	166	160	156	154	83	81	80
Total Number of ECU	34	34	34	34	34	34	34	34	34
ESS Weight (Kg)	549	484	444	426	414	407	392	382	376
ESS Volume (M^3)	9.302	9.302	9.302	9.302	9.302	9.302	9.302	9.302	9.302
LIFE CYCLE COSTS (1980$M)									
DDT&E Cost	7.167	7.051	6.883	6.946	7.012	7.096	6.724	6.750	6.788
Production Cost	17.036	16.693	16.320	16.344	16.396	16.481	15.927	15.930	15.960
Operations & Maintenance Cost	.500	.500	.500	.500	.500	.500	.500	.500	.500
	--------	--------	--------	--------	--------	--------	--------	--------	--------
ESS LIFE CYCLE COST	24.753	24.244	23.703	23.790	23.908	24.077	23.151	23.180	23.248
Solar Array Cost	19.701	19.436	19.701	19.399	19.410	19.510	19.701	19.436	19.403
Thermal Control Cost	6.400	6.310	6.400	6.246	6.144	6.069	6.400	6.310	6.246
Power Conditioning Cost	1.042	1.042	1.042	1.042	1.042	1.042	1.042	1.042	1.042
	--------	--------	--------	--------	--------	--------	--------	--------	--------
TOTAL LIFE CYCLE COST	51.896	51.032	50.846	50.477	50.504	50.698	50.294	49.968	49.939

Exhibit 19e. FCU Active Area

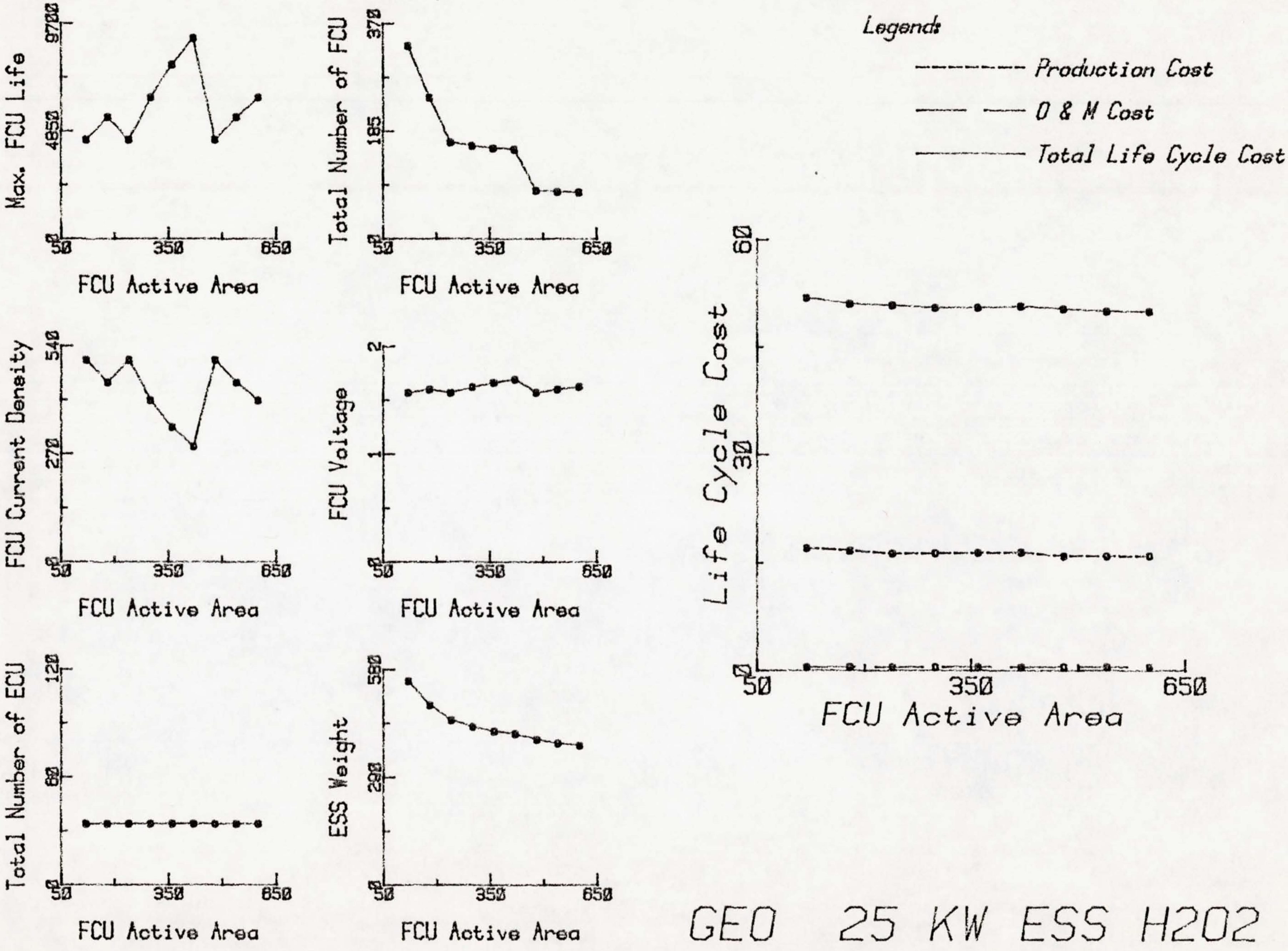

Exhibit 19e. FCU Active Area (Continued)

LEO 25KW ESS (H2O2)

EOL FCU PERFORMANCE									
Hardware Life Cycles	2	3	4	5	6	8	10	12	15
Maximum FCU Life (Hr)	32000	21500	16000	13000	10750	8000	6500	5400	4300
Dark Period Power (W)	22.17	33.84	43.46	57.14	69.29	88.37	116.21	119.39	122.58
Dark Period Voltage (V)	1.372	1.397	1.435	1.415	1.430	1.459	1.439	1.478	1.518
Active Cell Area (cm2)	232.26	232.26	232.26	232.26	232.26	232.26	232.26	232.26	232.26
Current Density (Ma/cm2)	69.56	104.34	130.43	173.90	208.68	260.85	347.80	347.80	347.80
Operating Pressure (Kg/cm2)	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125
Operating Temperature (Deg-K)	355	355	355	355	355	355	355	355	355
EOL ECU PERFORMANCE									
Light Period Power (W)	34.42	34.09	34.05	33.76	34.56	33.97	34.25	34.29	33.91
Light Period Voltage (V)	3.476	3.464	3.442	3.439	3.491	3.441	3.442	3.442	3.442
EOL SUBSYSTEM PERFORMANCE									
Hardware Life Cycles	4	4	4	4	4	4	4	4	4
Maximum Pump Life (Hr)	62393	62393	62393	62393	62393	62393	62393	62393	62393
H2 Storage Weight (Kg)	1.405	1.367	1.314	1.334	1.315	1.282	1.291	1.263	1.220
DoD Factor	.800	.800	.800	.800	.800	.800	.800	.800	.800
Watt-Hour Efficiency	.390	.405	.422	.419	.419	.435	.430	.442	.454
PHYSICAL CHARACTERISTICS									
Total Number of FCU	1410	930	720	552	455	356	270	264	255
Total Number of ECU	1598	1564	1496	1530	1496	1462	1462	1428	1394
ESS Weight (Kg)	2597	2241	2057	1984	1903	1823	1782	1726	1691
ESS Volume (M^3)	20.254	15.051	15.051	15.051	15.051	15.051	20.254	15.051	15.051
LIFE CYCLE COSTS (1980$M)									
DDT&E Cost	19.040	17.236	16.283	15.807	15.343	14.865	14.538	14.303	14.146
Production Cost	25.495	22.521	20.961	20.212	19.467	18.706	18.209	17.810	17.593
Operations & Maintenance Cost	39.645	42.337	43.798	45.452	46.134	48.465	49.629	53.446	59.133
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ESS LIFE CYCLE COST	84.180	82.094	81.042	81.471	80.944	82.036	82.376	85.559	90.872
Solar Array Cost	355.605	346.797	334.317	338.101	338.318	327.564	329.776	323.909	314.888
Thermal Control Cost	6.037	6.001	5.965	6.070	6.113	6.187	6.324	6.298	6.261
Power Conditioning Cost	1.988	1.409	1.166	.914	.783	.648	.508	.508	.508
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TOTAL LIFE CYCLE COST	447.810	436.301	422.490	426.556	426.158	416.435	418.984	416.274	412.529

Exhibit 20a. FCU Life

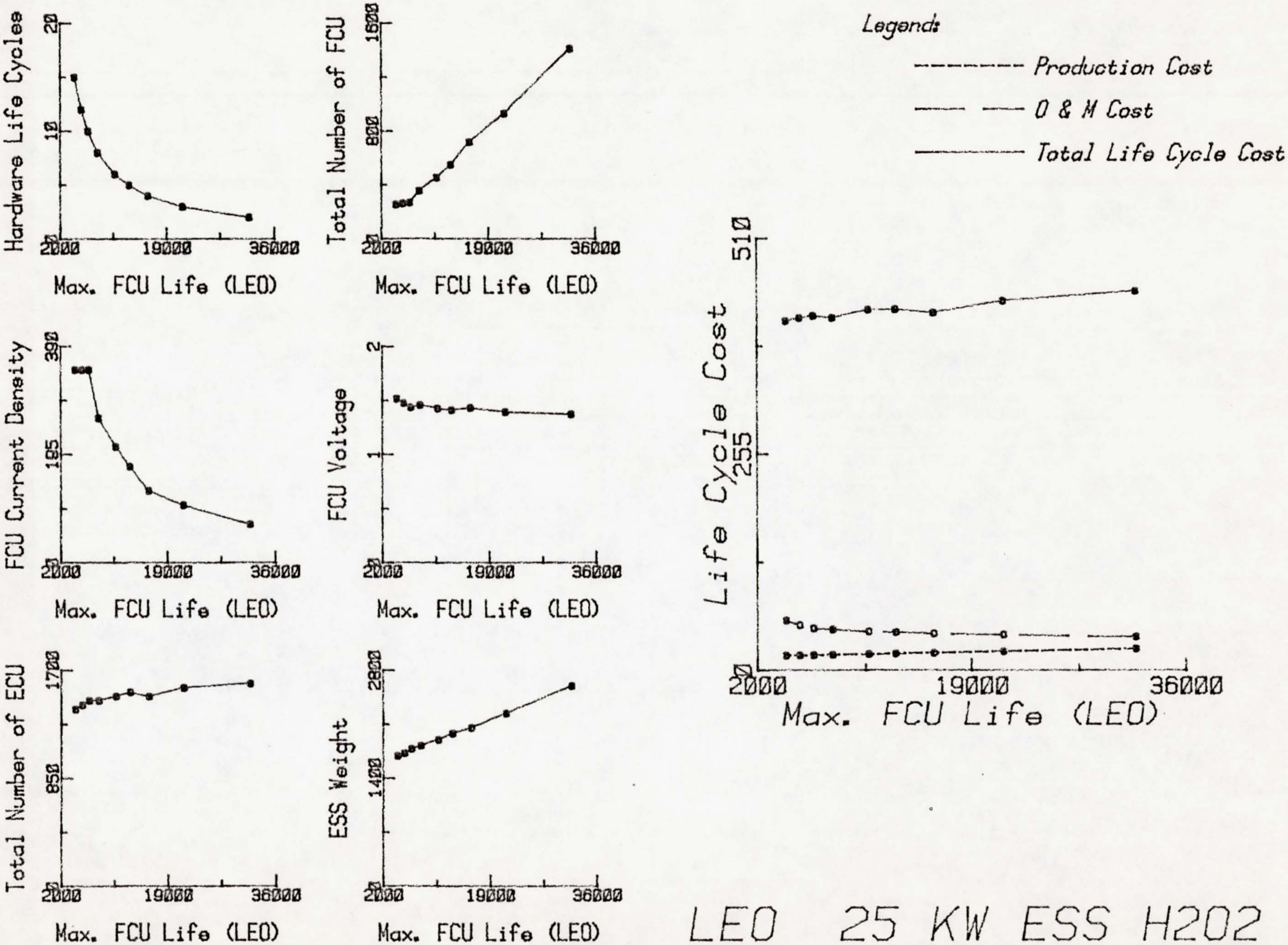

Exhibit 20a. FCU Life (Continued)

LEO 50KW ESS (H2O2)

EOL FCU PERFORMANCE									
Hardware Life Cycles	2	3	4	5	6	8	10	12	15
Maximum FCU Life (Hr)	32000	21500	16000	13000	10750	8000	6500	5400	4300
Dark Period Power (W)	22.17	33.84	45.66	57.14	75.42	98.81	116.21	138.21	142.29
Dark Period Voltage (V)	1.372	1.397	1.413	1.415	1.400	1.427	1.439	1.426	1.468
Active Cell Area (cm2)	232.26	232.26	232.26	232.26	232.26	232.26	232.26	232.26	232.26
Current Density (Ma/cm2)	69.56	104.34	139.12	173.90	231.87	298.12	347.81	417.37	417.37
Operating Pressure (Kg/cm2)	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125
Operating Temperature (Deg-K)	355	355	355	355	355	355	355	355	355
EOL ECU PERFORMANCE									
Light Period Power (W)	34.42	34.48	34.71	34.16	34.19	34.84	34.25	34.56	34.62
Light Period Voltage (V)	3.476	3.464	3.477	3.439	3.462	3.496	3.442	3.481	3.481
EOL SUBSYSTEM PERFORMANCE									
Hardware Life Cycles	4	4	4	4	4	4	4	4	4
Maximum Pump Life (Hr)	62393	62393	62393	62393	62393	62393	62393	62393	62393
H2 Storage Weight (Kg)	2.810	2.734	2.681	2.668	2.654	2.616	2.583	2.607	2.521
DoD Factor	.800	.800	.800	.800	.800	.800	.800	.800	.800
Watt-Hour Efficiency	.390	.405	.412	.419	.414	.419	.430	.422	.435
PHYSICAL CHARACTERISTICS									
Total Number of FCU	2820	1860	1380	1104	828	637	540	455	440
Total Number of ECU	3196	3094	3026	3026	3026	2958	2924	2958	2856
ESS Weight (Kg)	5162	4454	4102	3941	3783	3607	3532	3521	3405
ESS Volume (M^3)	31.206	26.003	20.800	20.800	20.800	20.800	31.206	26.003	20.800
LIFE CYCLE COSTS (1980$M)									
DDT&E Cost	28.910	25.645	23.950	23.073	22.160	21.241	20.805	20.613	20.164
Production Cost	44.686	39.058	36.162	34.700	33.198	31.653	30.936	30.661	29.351
Operations & Maintenance Cost	71.764	75.746	77.983	80.484	80.027	82.667	86.185	89.231	96.813
	--------	--------	--------	--------	--------	--------	--------	--------	--------
ESS LIFE CYCLE COST	145.360	140.449	138.095	138.257	135.385	135.561	137.926	140.505	146.823
Solar Array Cost	620.429	605.283	597.829	590.126	590.627	588.651	575.390	584.993	569.431
Thermal Control Cost	6.875	6.803	6.779	6.938	7.133	7.321	7.447	7.656	7.575
Power Conditioning Cost	3.578	2.537	1.988	1.645	1.289	1.042	.914	.783	.783
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TOTAL LIFE CYCLE COST	776.242	755.072	744.691	736.966	734.434	732.575	721.677	733.937	724.667

Exhibit 20b. FCU Life

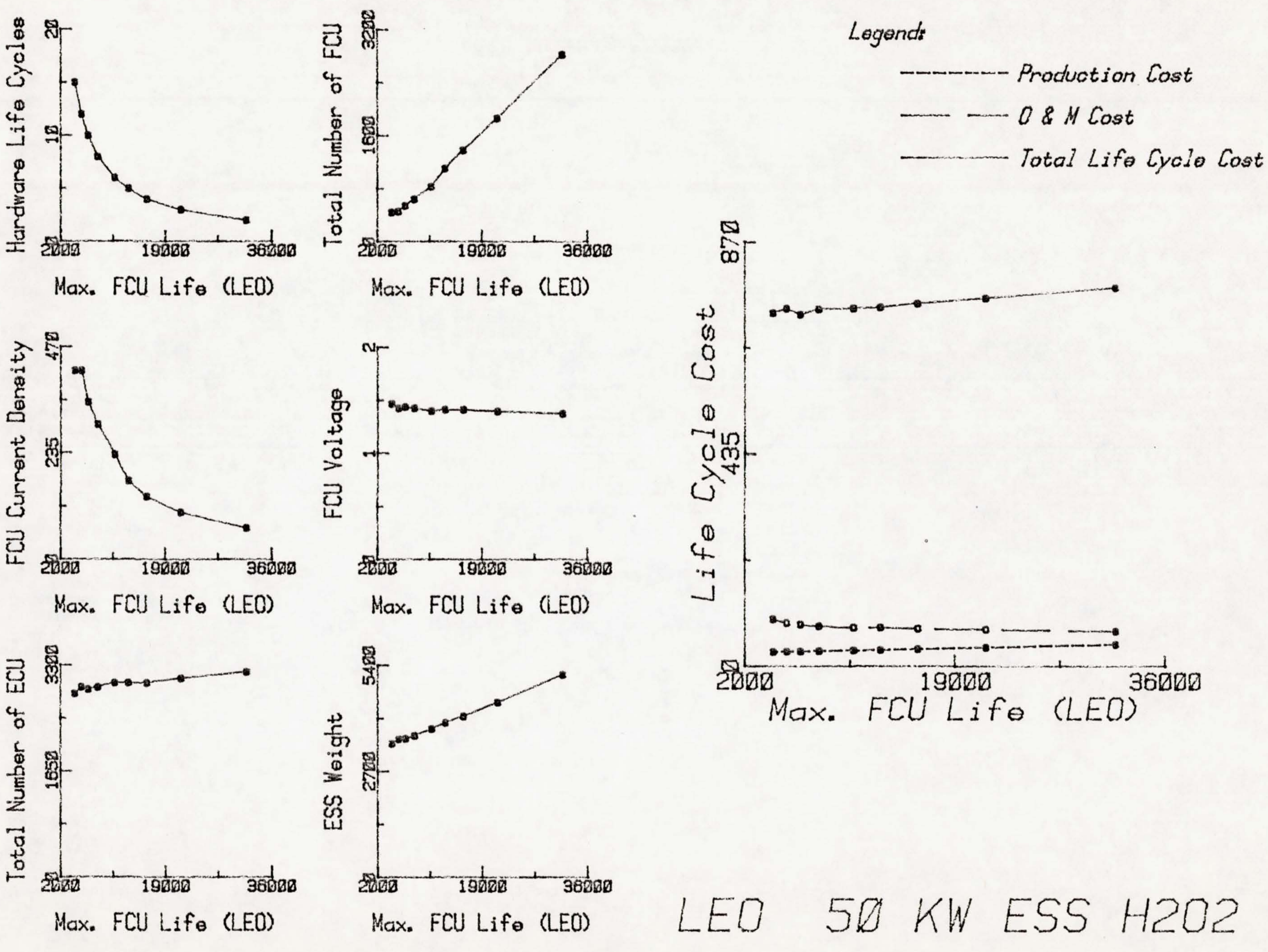

Exhibit 20b. FCU Life (Continued)

LEO 100KW ESS (H2O2)

EOL FCU PERFORMANCE									
Hardware Life Cycles	2	3	4	5	6	8	10	12	15
Maximum FCU Life (Hr)	32000	21500	16000	13000	10750	8000	6500	5400	4300
Dark Period Power (W)	22.17	33.84	46.83	59.12	75.42	104.95	124.63	138.21	154.67
Dark Period Voltage (V)	1.372	1.397	1.401	1.403	1.400	1.408	1.414	1.426	1.436
Active Cell Area (cm2)	232.26	232.26	232.26	232.26	232.26	232.26	232.26	232.26	232.26
Current Density (Ma/cm2)	69.56	104.34	143.92	181.46	231.87	321.05	379.42	417.37	463.75
Operating Pressure (Kg/cm2)	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125
Operating Temperature (Deg-K)	355	355	355	355	355	355	355	355	355
EOL ECU PERFORMANCE									
Light Period Power (W)	34.61	34.48	34.87	34.44	34.39	34.49	34.65	34.56	34.60
Light Period Voltage (V)	3.476	3.464	3.496	3.451	3.462	3.466	3.489	3.481	3.436
EOL SUBSYSTEM PERFORMANCE									
Hardware Life Cycles	4	4	4	4	4	4	4	4	4
Maximum Pump Life (Hr)	62393	62393	62393	62393	62393	62393	62393	62393	62393
H2 Storage Weight (Kg)	5.619	5.467	5.358	5.331	5.308	5.285	5.276	5.214	5.153
DoD Factor	.800	.800	.800	.800	.800	.800	.800	.800	.800
Watt-Hour Efficiency	.390	.405	.406	.414	.414	.418	.418	.422	.425
PHYSICAL CHARACTERISTICS									
Total Number of FCU	5640	3720	2668	2116	1656	1196	1012	910	810
Total Number of ECU	6358	6188	6052	6018	6018	5984	5984	5916	5848
ESS Weight (Kg)	10296	8902	8118	7775	7512	7249	7134	7035	6912
ESS Volume (M^3)	53.656	48.453	37.501	37.501	37.501	37.501	53.656	48.453	37.501
LIFE CYCLE COSTS (1980$M)									
DDT&E Cost	42.900	37.590	34.478	32.943	31.703	30.363	29.784	29.320	28.790
Production Cost	81.186	70.668	64.550	61.614	59.266	56.768	55.684	54.802	53.773
Operations & Maintenance Cost	131.740	139.045	141.316	144.488	144.908	147.354	153.434	159.381	168.615
ESS LIFE CYCLE COST	255.826	247.303	240.344	239.045	235.877	234.485	238.902	243.503	251.178
Solar Array Cost	1082.659	1056.034	1046.871	1031.794	1030.654	1028.216	1032.198	1020.656	1012.073
Thermal Control Cost	8.548	8.407	8.408	8.728	9.064	9.640	9.945	10.111	10.283
Power Conditioning Cost	6.440	4.566	3.477	2.856	2.320	1.761	1.528	1.409	1.289
TOTAL LIFE CYCLE COST	1353.473	1316.310	1299.100	1282.423	1277.915	1274.102	1282.573	1275.679	1274.823

Exhibit 20c. FCU Life

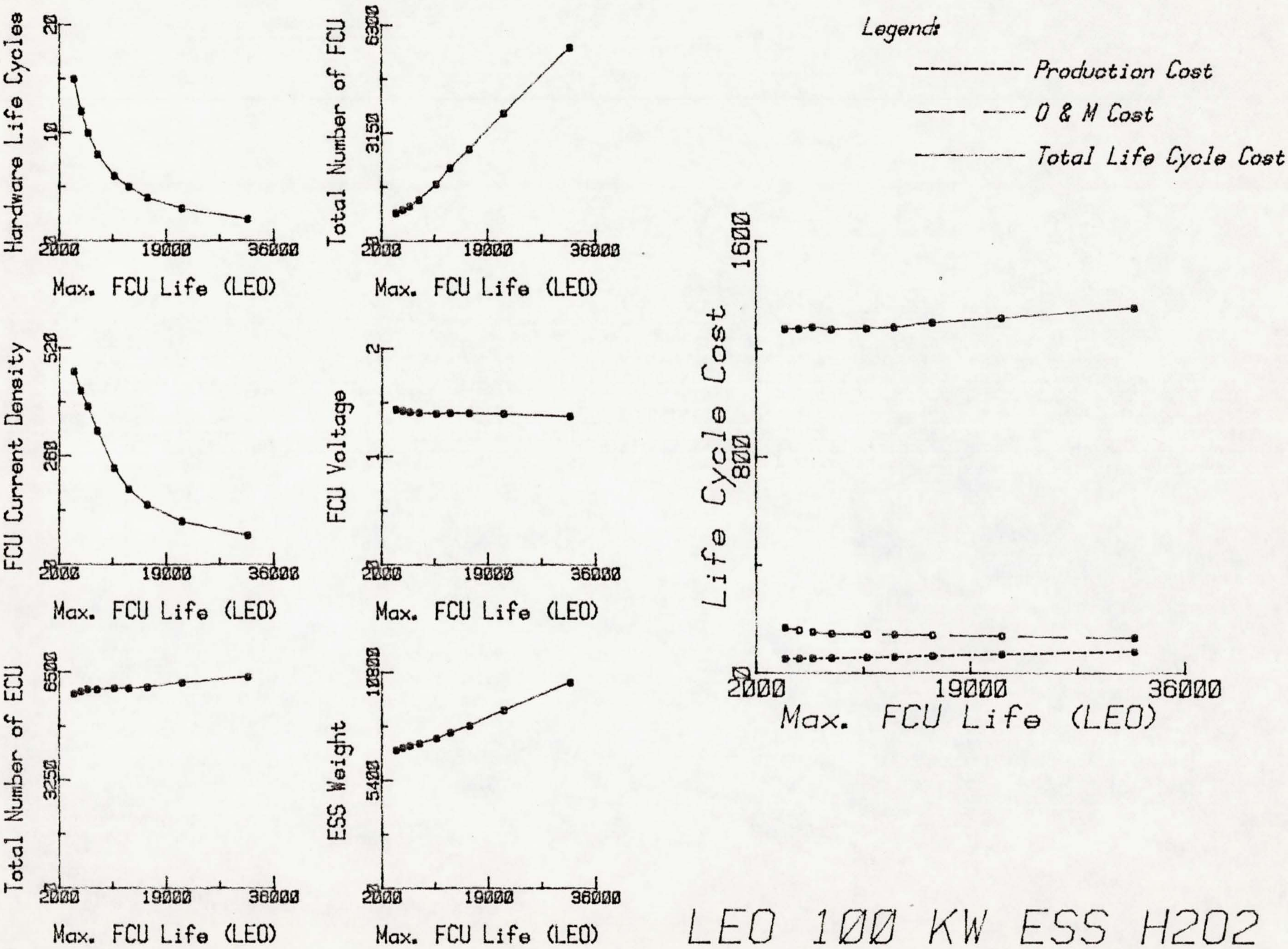

Exhibit 20c. FCU Life (Continued)

LEO 250KW ESS (H2O2)

EOL FCU PERFORMANCE									
Hardware Life Cycles	2	3	4	5	6	8	10	12	15
Maximum FCU Life (Hr)	32000	21500	16000	13000	10750	8000	6500	5400	4300
Dark Period Power (W)	22.27	34.09	46.60	59.54	75.42	106.27	126.45	142.65	162.98
Dark Period Voltage (V)	1.369	1.393	1.404	1.400	1.400	1.403	1.409	1.413	1.412
Active Cell Area (cm2)	232.26	232.26	232.26	232.26	232.26	232.26	232.26	232.26	232.26
Current Density (Ma/cm2)	70.03	105.40	142.94	183.06	231.88	326.07	386.46	434.77	496.86
Operating Pressure (Kg/cm2)	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125
Operating Temperature (Deg-K)	355	355	355	355	355	355	355	355	355
EOL ECU PERFORMANCE									
Light Period Power (W)	34.64	34.56	34.84	34.42	34.52	34.64	34.92	34.32	34.64
Light Period Voltage (V)	3.477	3.466	3.492	3.453	3.462	3.474	3.499	3.443	3.471
EOL SUBSYSTEM PERFORMANCE									
Hardware Life Cycles	4	4	4	4	4	4	4	4	4
Maximum Pump Life (Hr)	62393	62393	62393	62393	62393	62393	62393	62393	62393
H2 Storage Weight (Kg)	14.193	13.664	13.398	13.325	13.270	13.211	13.189	13.175	13.160
DoD Factor	.800	.800	.800	.800	.800	.800	.800	.800	.800
Watt-Hour Efficiency	.389	.404	.408	.414	.414	.415	.415	.423	.420
PHYSICAL CHARACTERISTICS									
Total Number of FCU	14155	9207	6716	5244	4140	2944	2484	2208	1932
Total Number of ECU	16048	15436	15130	15062	14994	14926	14892	14892	14858
ESS Weight (Kg)	25889	22168	20304	19403	18705	18036	17765	17651	17522
ESS Volume (M^3)	125.660	109.510	88.151	82.948	82.948	77.199	125.660	109.510	88.151
LIFE CYCLE COSTS (1980$M)									
DDT&E Cost	70.722	60.807	55.661	52.833	50.609	48.201	47.213	46.677	46.069
Production Cost	185.928	159.648	146.099	138.878	133.213	127.242	124.797	123.534	122.103
Operations & Maintenance Cost	302.525	314.768	320.853	325.978	326.044	328.585	339.992	352.603	370.276
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ESS LIFE CYCLE COST	559.175	535.223	522.613	517.689	509.866	504.028	512.002	522.814	538.448
Solar Array Cost	2278.706	2204.610	2183.324	2154.221	2151.344	2149.696	2159.499	2129.948	2142.076
Thermal Control Cost	13.654	13.211	13.194	14.048	14.858	16.374	17.152	17.842	18.612
Power Conditioning Cost	13.928	9.848	7.606	6.166	5.046	3.779	3.272	2.961	2.644
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TOTAL LIFE CYCLE COST	2865.463	2762.892	2726.737	2692.124	2681.114	2673.877	2691.925	2673.565	2701.780

Exhibit 20d. FCU Life

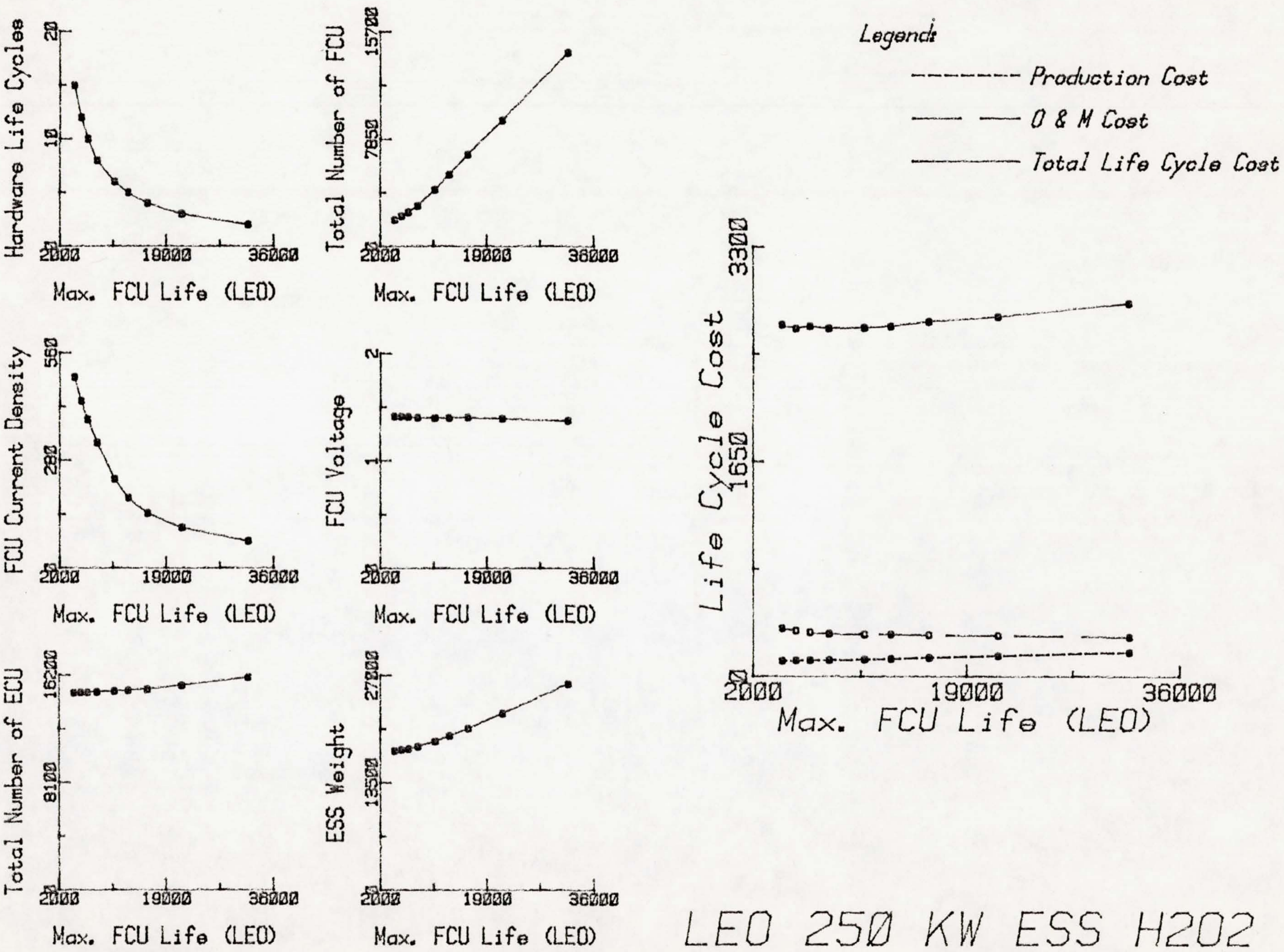

Exhibit 20d. FCU Life (Continued)

LEO 25KW ESS (H2O2)

EOL FCU PERFORMANCE									
Hardware Life Cycles	2	3	4	5	6	8	10	12	15
Maximum FCU Life (Hr)	32250	21798	17436	13514	11732	9755	7578	7578	7578
Dark Period Power (W)	22.22	33.99	43.53	57.45	69.50	88.46	116.61	119.68	122.75
Dark Period Voltage (V)	1.375	1.403	1.437	1.422	1.434	1.460	1.444	1.482	1.520
Active Cell Area (cm2)	232.26	232.26	232.26	232.26	232.26	232.26	232.26	232.26	232.26
Current Density (Ma/cm2)	69.56	104.34	130.43	173.90	208.68	260.85	347.80	347.80	347.80
Operating Pressure (Kg/cm2)	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125
Operating Temperature (Deg-K)	355	355	355	355	355	355	355	355	355
EOL ECU PERFORMANCE									
Light Period Power (W)	34.42	34.49	34.05	34.17	34.16	33.97	34.25	33.88	33.91
Light Period Voltage (V)	3.476	3.464	3.442	3.439	3.491	3.441	3.442	3.442	3.442
EOL SUBSYSTEM PERFORMANCE									
Hardware Life Cycles	4	4	4	4	4	4	4	4	4
Maximum Pump Life (Hr)	62393	62393	62393	62393	62393	62393	62393	62393	62393
H2 Storage Weight (Kg)	1.405	1.352	1.314	1.319	1.300	1.282	1.291	1.248	1.220
DoD Factor	.800	.800	.800	.800	.800	.800	.800	.800	.800
Watt-Hour Efficiency	.391	.407	.423	.421	.420	.435	.432	.443	.455
PHYSICAL CHARACTERISTICS									
Total Number of FCU	1410	920	720	546	450	356	270	261	255
Total Number of ECU	1598	1530	1496	1495	1496	1462	1462	1423	1394
ESS Weight (Kg)	2597	2211	2057	1956	1898	1823	1782	1721	1691
ESS Volume (M^3)	20.254	15.051	15.051	15.051	15.051	15.051	20.254	15.051	15.051
LIFE CYCLE COSTS (1980$M)									
DDT&E Cost	19.040	17.089	16.283	15.669	15.320	14.865	14.539	14.284	14.146
Production Cost	25.496	22.276	20.962	19.986	19.428	18.706	18.211	17.778	17.594
Operations & Maintenance Cost	39.646	41.702	43.798	44.786	45.994	48.465	49.630	53.250	59.134
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ESS LIFE CYCLE COST	84.182	81.067	81.043	80.441	80.742	82.036	82.380	85.312	90.874
Solar Array Cost	355.605	343.913	334.317	335.263	335.233	327.564	329.776	320.816	314.388
Thermal Control Cost	6.037	5.994	5.965	6.060	6.103	6.187	6.324	6.286	6.261
Power Conditioning Cost	1.988	1.409	1.166	.914	.783	.648	.508	.508	.508
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TOTAL LIFE CYCLE COST	447.812	432.383	422.491	422.678	422.861	416.435	418.988	412.922	412.531

Exhibit 21a. FCU Hardware Life Cycles

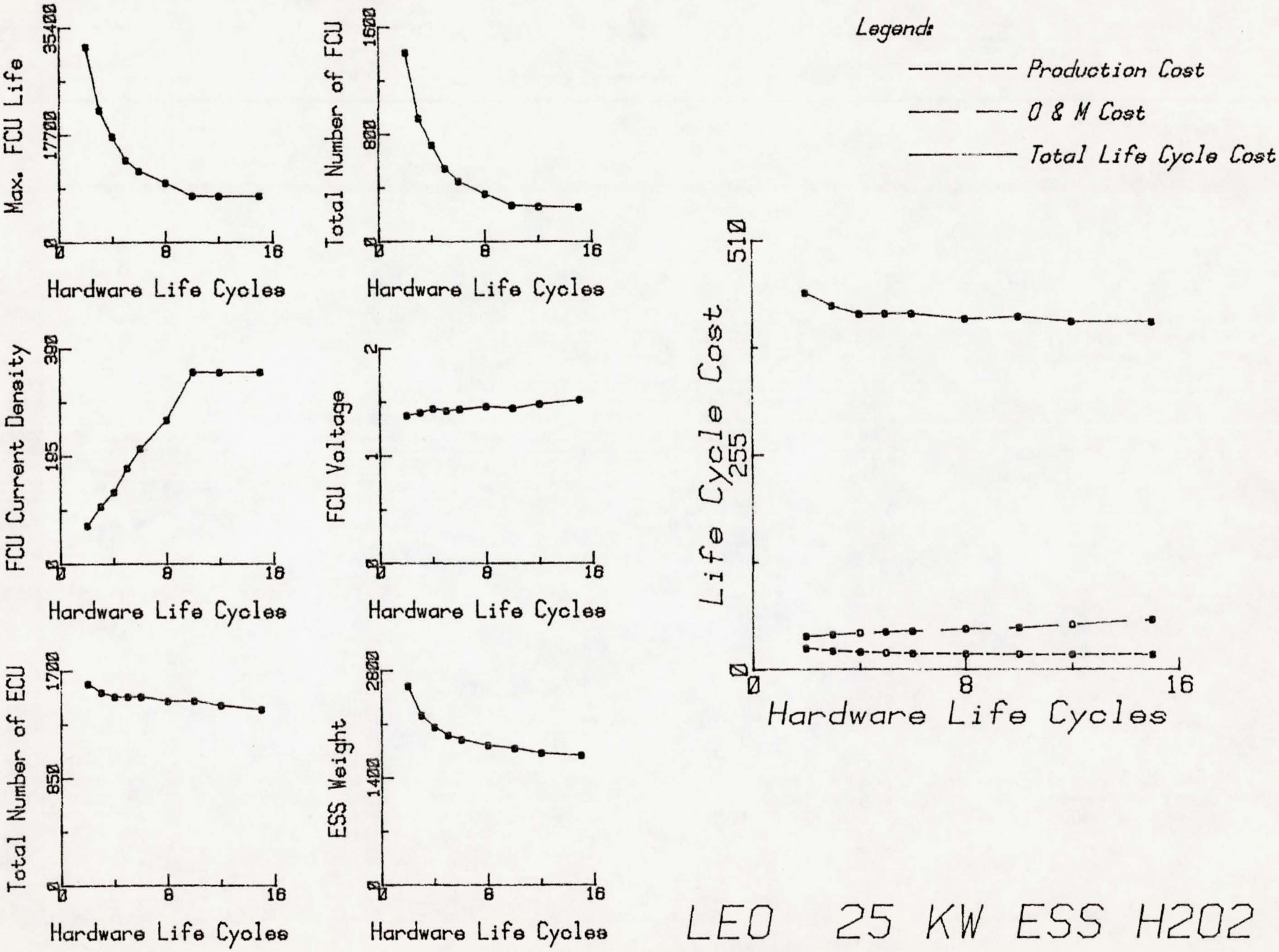

Exhibit 21a. FCU Hardware Life Cycles (Continued)

LEO 50KW ESS (H2O2)

EOL FCU PERFORMANCE									
Hardware Life Cycles	2	3	4	5	6	8	10	12	15
Maximum FCU Life (Hr)	32250	21798	16542	13514	10787	8791	7578	6083	6083
Dark Period Power (W)	22.22	33.99	45.73	57.45	75.67	98.92	116.60	138.57	142.50
Dark Period Voltage (V)	1.375	1.403	1.415	1.422	1.405	1.429	1.443	1.430	1.470
Active Cell Area (cm2)	232.26	232.26	232.26	232.26	232.26	232.26	232.26	232.26	232.26
Current Density (Ma/cm2)	69.56	104.34	139.12	173.90	231.87	298.12	347.81	417.37	417.37
Operating Pressure (Kg/cm2)	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125
Operating Temperature (Deg-K)	355	355	355	355	355	355	355	355	355
EOL ECU PERFORMANCE									
Light Period Power (W)	34.42	34.49	34.71	34.17	34.19	34.84	34.25	34.56	34.62
Light Period Voltage (V)	3.476	3.464	3.477	3.439	3.462	3.496	3.442	3.481	3.481
EOL SUBSYSTEM PERFORMANCE									
Hardware Life Cycles	4	4	4	4	4	4	4	4	4
Maximum Pump Life (Hr)	62393	62393	62393	62393	62393	62393	62393	62393	62393
H2 Storage Weight (Kg)	2.810	2.704	2.681	2.639	2.654	2.616	2.583	2.607	2.521
DoD Factor	.800	.800	.800	.800	.800	.800	.800	.800	.800
Watt-Hour Efficiency	.391	.407	.413	.421	.416	.420	.432	.423	.435
PHYSICAL CHARACTERISTICS									
Total Number of FCU	2820	1840	1380	1092	828	637	540	455	440
Total Number of ECU	3196	3060	3026	2992	3026	2958	2924	2958	2856
ESS Weight (Kg)	5162	4416	4102	3882	3783	3607	3532	3521	3405
ESS Volume (M^3)	31.206	26.003	20.800	20.800	20.800	20.800	31.206	26.003	20.800
LIFE CYCLE COSTS (1980$M)									
DDT&E Cost	28.912	25.474	23.952	22.837	22.163	21.242	20.809	20.616	20.166
Production Cost	44.690	38.763	36.165	34.281	33.203	31.654	30.941	30.665	29.853
Operations & Maintenance Cost	71.766	75.040	77.985	79.729	80.030	82.668	86.188	89.234	96.814
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ESS LIFE CYCLE COST	145.368	139.277	138.102	136.847	135.396	135.564	137.938	140.515	146.833
Solar Array Cost	620.429	600.059	597.829	584.967	590.627	588.651	575.390	584.993	569.481
Thermal Control Cost	6.875	6.786	6.779	6.919	7.133	7.321	7.447	7.656	7.575
Power Conditioning Cost	3.578	2.537	1.988	1.645	1.289	1.042	.914	.783	.783
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TOTAL LIFE CYCLE COST	776.250	748.659	744.698	730.378	734.445	732.573	721.689	733.947	724.672

Exhibit 21b. FCU Hardware Life Cycles

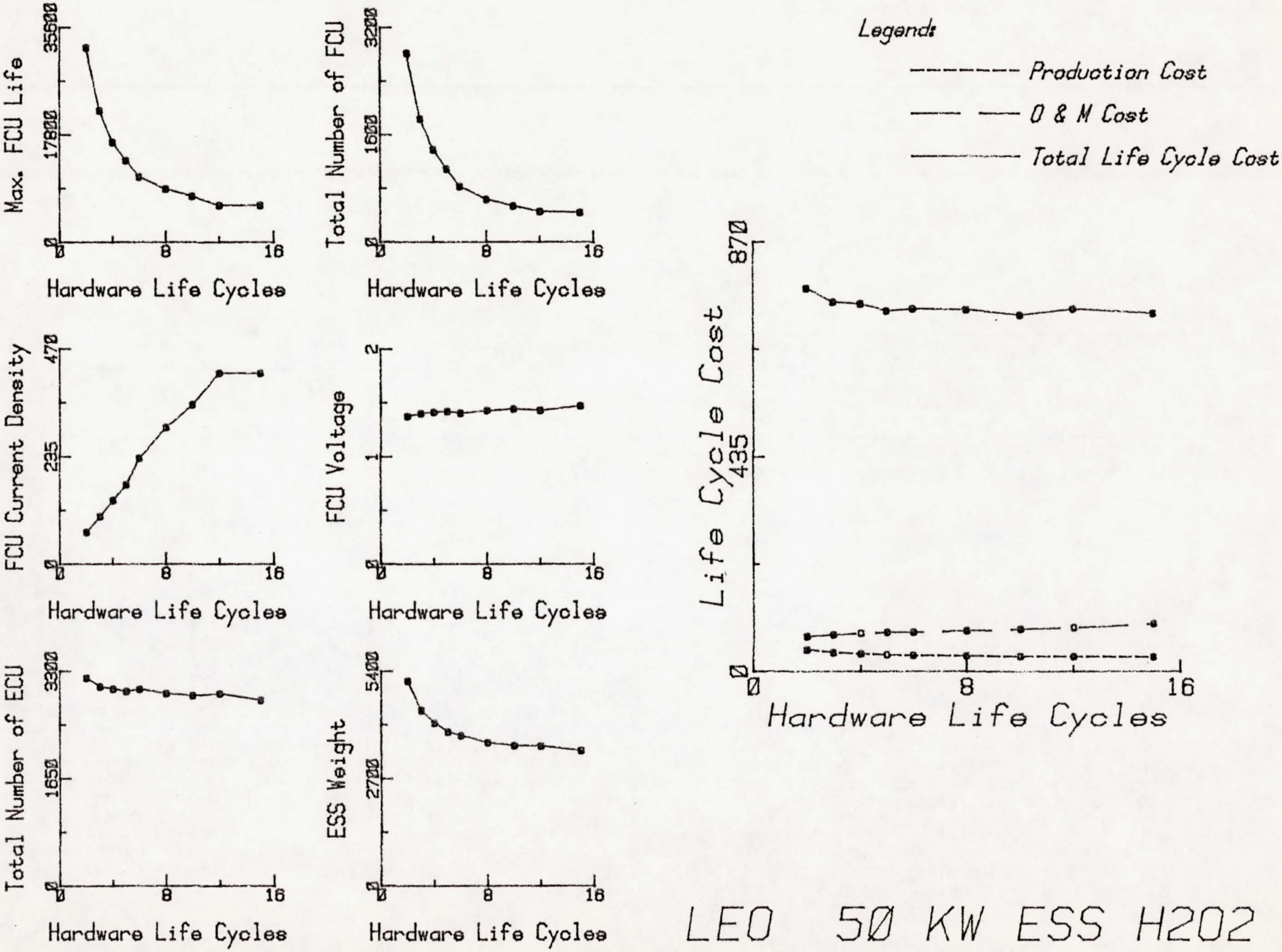

Exhibit 21b. FCU Hardware Life Cycles (Continued)

LEO 100KW ESS (H202)

EOL FCU PERFORMANCE									
Hardware Life Cycles	2	3	4	5	6	8	10	12	15
Maximum FCU Life (Hr)	32250	21341	16047	13127	10787	8225	6891	6083	5207
Dark Period Power (W)	22.22	34.62	46.91	59.46	75.67	105.07	125.07	138.57	154.92
Dark Period Voltage (V)	1.375	1.393	1.403	1.411	1.405	1.409	1.419	1.430	1.438
Active Cell Area (cm2)	232.26	232.26	232.26	232.26	232.26	232.26	232.26	232.26	232.26
Current Density (Ma/cm2)	69.56	107.02	143.92	181.46	231.87	321.05	379.42	417.37	463.75
Operating Pressure (Kg/cm2)	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125
Operating Temperature (Deg-K)	355	355	355	355	355	355	355	355	355
EOL ECU PERFORMANCE									
Light Period Power (W)	34.61	34.49	34.87	34.44	34.39	34.49	34.67	34.56	34.60
Light Period Voltage (V)	3.476	3.468	3.496	3.451	3.462	3.466	3.489	3.481	3.486
EOL SUBSYSTEM PERFORMANCE									
Hardware Life Cycles	4	4	4	4	4	4	4	4	4
Maximum Pump Life (Hr)	62393	62393	62393	62393	62393	62393	62393	62393	62393
H2 Storage Weight (Kg)	5.619	5.462	5.358	5.331	5.308	5.285	5.219	5.214	5.153
DoD Factor	.800	.800	.800	.800	.800	.800	.800	.800	.800
Watt-Hour Efficiency	.391	.404	.407	.417	.416	.418	.419	.423	.426
PHYSICAL CHARACTERISTICS									
Total Number of FCU	5640	3627	2668	2116	1656	1196	1001	910	810
Total Number of ECU	6358	6188	6052	6018	6018	5984	5916	5916	5848
ESS Weight (Kg)	10296	8842	8118	7775	7512	7249	7074	7035	6912
ESS Volume (M^3)	53.656	48.453	37.501	37.501	37.501	37.501	53.656	48.453	37.501
LIFE CYCLE COSTS (1980$M)									
DDT&E Cost	42.903	37.352	34.482	32.954	31.709	30.365	29.570	29.325	28.793
Production Cost	81.192	70.198	64.555	61.630	59.276	56.771	55.250	54.809	53.778
Operations & Maintenance Cost	131.744	138.147	141.319	144.498	144.915	147.356	151.965	159.385	168.618
ESS LIFE CYCLE COST	255.839	245.697	240.356	239.082	235.900	234.492	236.785	243.519	251.189
Solar Array Cost	1082.659	1056.291	1046.871	1031.794	1030.654	1028.216	1023.230	1020.656	1012.073
Thermal Control Cost	8.548	8.401	8.408	8.728	9.064	9.640	9.893	10.111	10.283
Power Conditioning Cost	6.440	4.469	3.477	2.856	2.320	1.761	1.528	1.409	1.289
TOTAL LIFE CYCLE COST	1353.486	1314.858	1299.112	1282.460	1277.938	1274.109	1271.436	1275.695	1274.834

Exhibit 21c. FCU Hardware Life Cycles

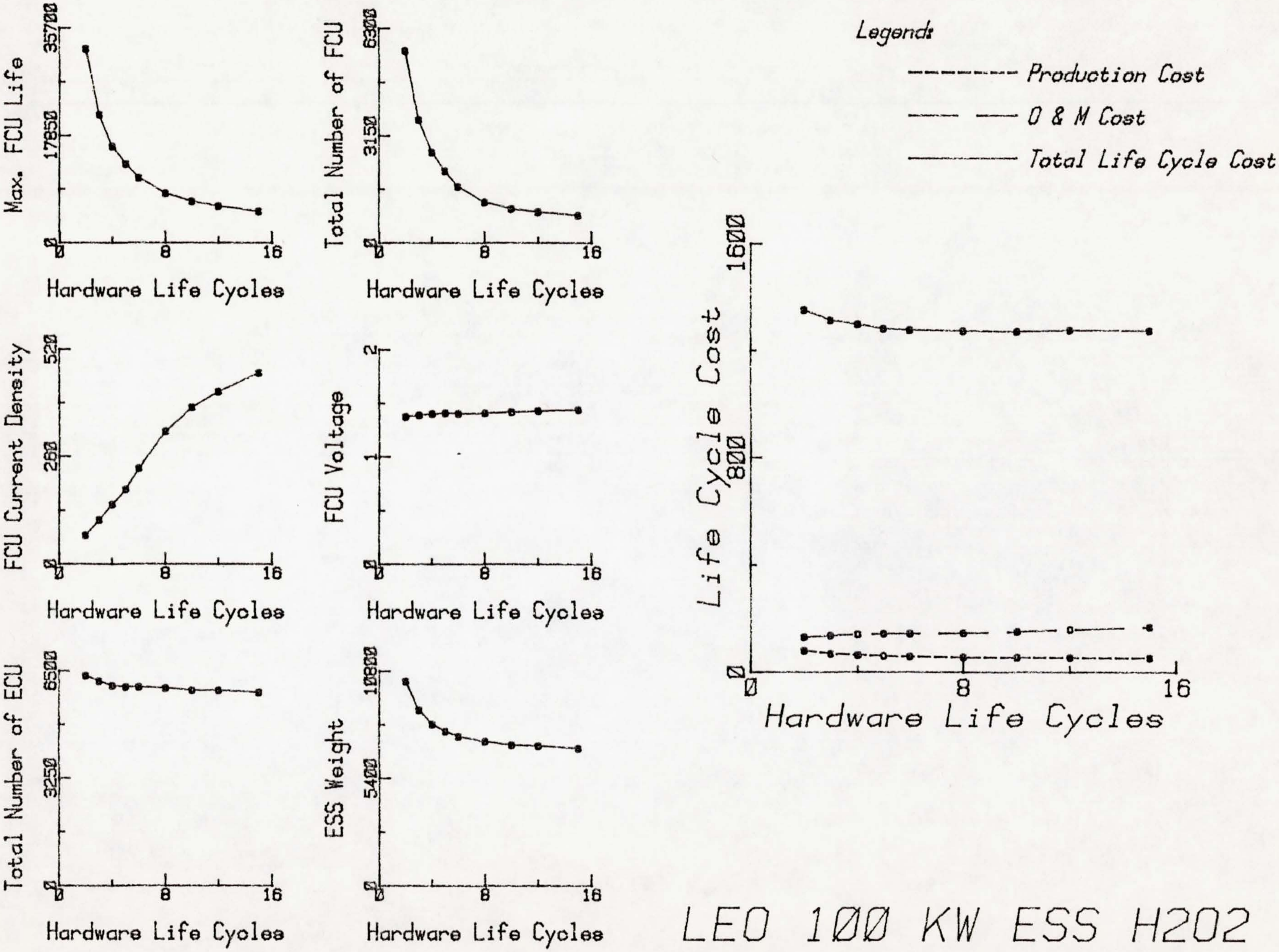

Exhibit 21c. FCU Hardware Life Cycles (Continued)

LEO 250KW ESS (H2O2)

EOL FCU PERFORMANCE									
Hardware Life Cycles	2	3	4	5	6	8	10	12	15
Maximum FCU Life (Hr)	31832	21247	15944	12877	10787	8102	6423	5389	4608
Dark Period Power (W)	22.42	34.75	47.15	60.73	75.67	106.39	130.66	147.84	163.26
Dark Period Voltage (V)	1.369	1.391	1.401	1.403	1.405	1.405	1.402	1.403	1.415
Active Cell Area (cm2)	232.26	232.26	232.26	232.26	232.26	232.26	232.26	232.26	232.26
Current Density (Ma/cm2)	70.50	107.57	144.92	186.33	231.88	326.07	401.33	453.67	496.86
Operating Pressure (Kg/cm2)	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125
Operating Temperature (Deg-K)	355	355	355	355	355	355	355	355	355
EOL ECU PERFORMANCE									
Light Period Power (W)	34.71	34.57	34.91	34.45	34.52	34.64	34.49	34.59	34.64
Light Period Voltage (V)	3.478	3.469	3.500	3.458	3.462	3.474	3.457	3.471	3.471
EOL SUBSYSTEM PERFORMANCE									
Hardware Life Cycles	4	4	4	4	4	4	4	4	4
Maximum Pump Life (Hr)	62393	62393	62393	62393	62393	62393	62393	62393	62393
H2 Storage Weight (Kg)	14.188	13.655	13.393	13.320	13.270	13.211	13.184	13.170	13.160
DoD Factor	.800	.800	.800	.800	.800	.800	.800	.800	.800
Watt-Hour Efficiency	.389	.403	.406	.414	.416	.416	.418	.417	.421
PHYSICAL CHARACTERISTICS									
Total Number of FCU	14060	9021	6624	5152	4140	2944	2392	2116	1932
Total Number of ECU	16014	15436	15130	15062	14994	14926	14892	14892	14858
ESS Weight (Kg)	25807	22049	20250	19349	18705	18036	17727	17612	17522
ESS Volume (M^3)	125.660	109.510	88.151	82.948	82.948	77.199	125.660	109.510	88.151
LIFE CYCLE COSTS (1980$M)									
DDT&E Cost	70.503	60.468	55.487	52.667	50.620	48.205	47.011	46.467	46.075
Production Cost	185.348	158.768	145.659	138.454	133.237	127.251	124.333	123.049	122.116
Operations & Maintenance Cost	301.675	313.097	319.603	324.295	326.059	328.591	336.010	347.656	370.284
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ESS LIFE CYCLE COST	557.526	532.333	520.749	515.416	509.916	504.047	507.354	517.172	538.475
Solar Array Cost	2278.595	2205.082	2186.613	2155.993	2151.344	2149.696	2138.091	2143.025	2142.076
Thermal Control Cost	13.650	13.200	13.247	14.102	14.858	16.374	17.382	18.071	18.612
Power Conditioning Cost	13.849	9.679	7.517	6.074	5.046	3.779	3.169	2.856	2.644
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TOTAL LIFE CYCLE COST	2863.620	2760.294	2728.126	2691.585	2681.164	2673.896	2665.996	2681.124	2701.807

Exhibit 21d. FCU Hardware Life Cycles

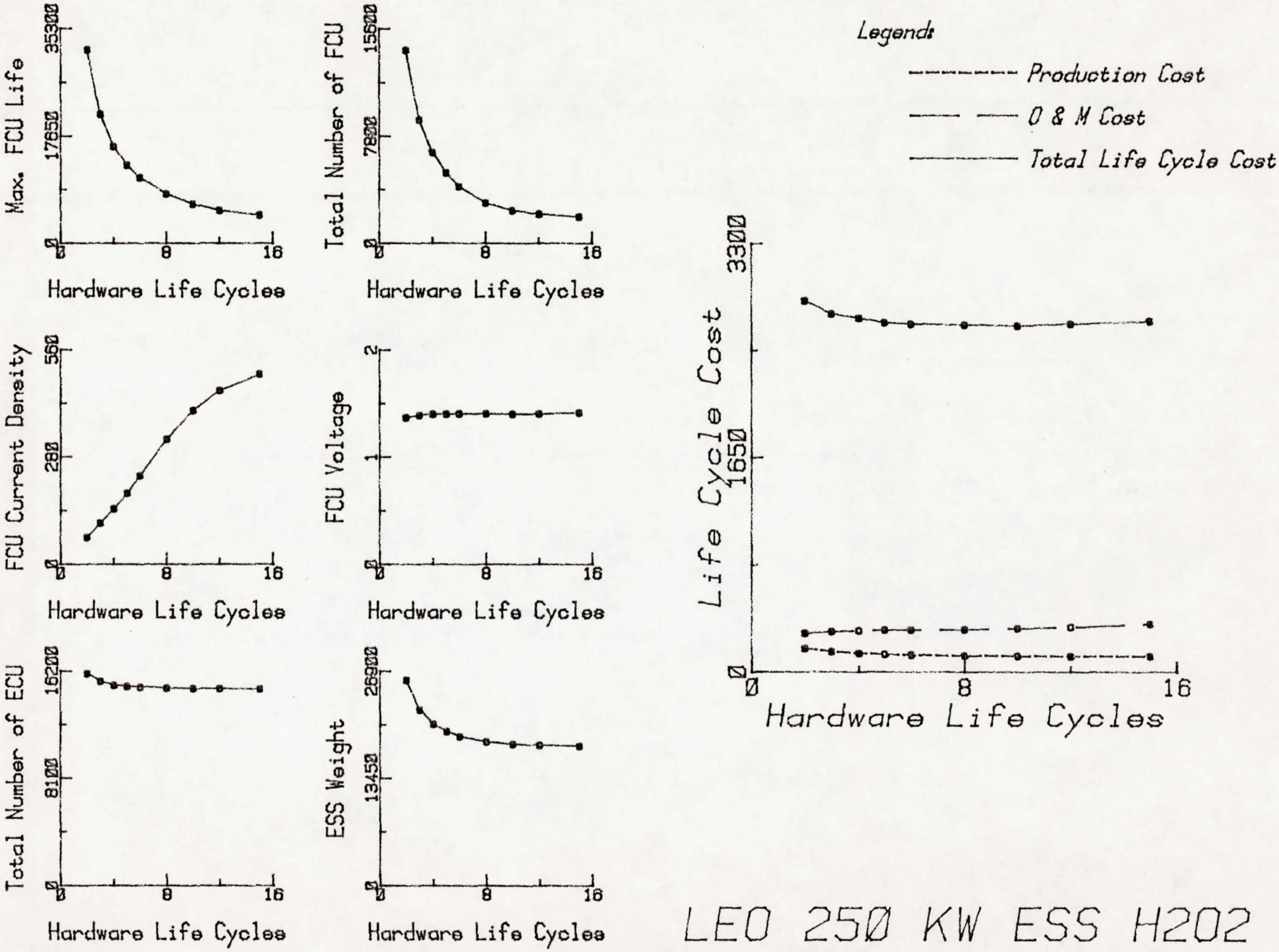

Exhibit 21d. FCU Hardware Life Cycles (Continued)